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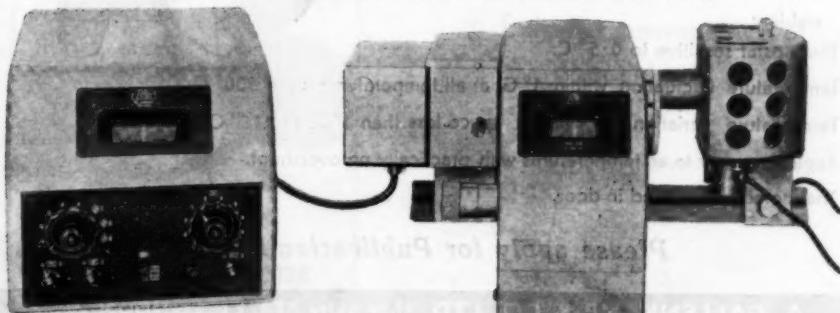
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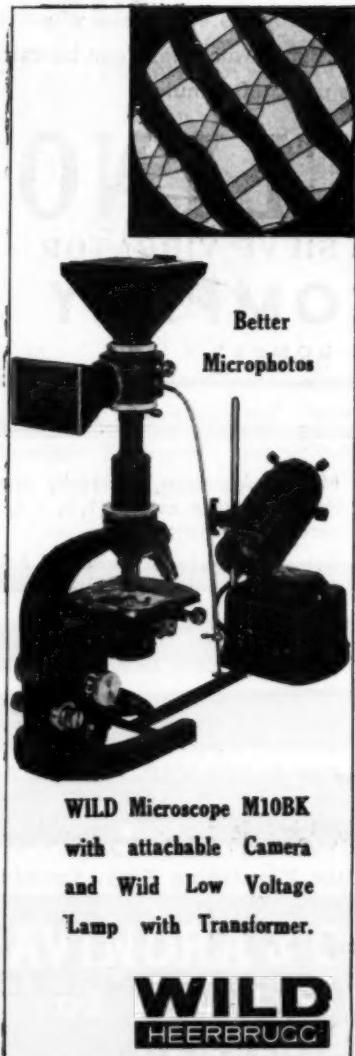
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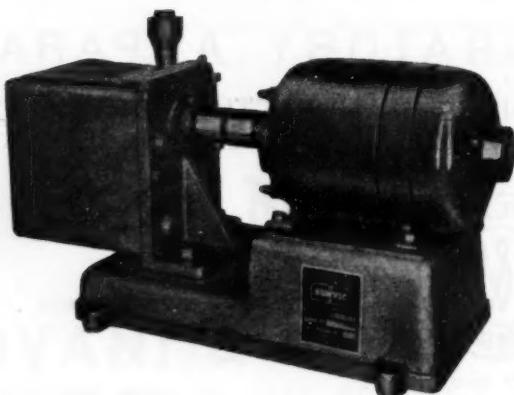
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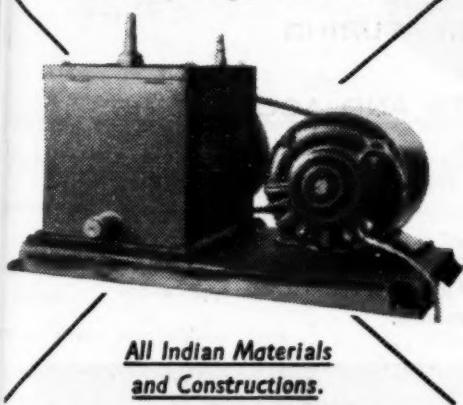
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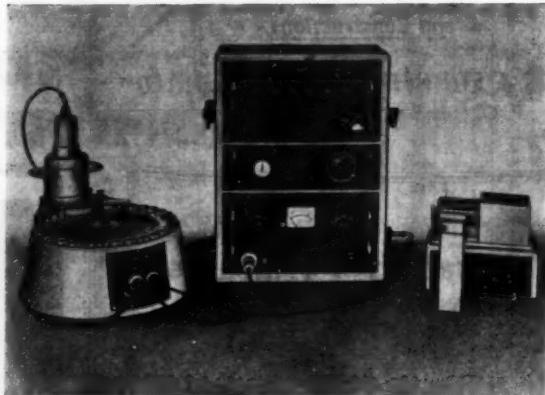
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THE THERMAL ENERGY OF CRYSTALS*

BY SIR C. V. RAMAN

THE determination of the nature of the atomic movements which constitute the thermal agitation in a crystal is a fundamental problem in the physics of the solid state. Its importance will be evident when it is remarked that even the most familiar aspects of the thermal behaviour of solids depend for their explanation on the precise nature of these movements. The subject also stands in the closest relationship with the spectroscopic behaviour of crystals and with X-ray crystallography, to say nothing of various other branches of physics.

Since the atomic movements under consideration are of thermal origin and are presumably in the nature of vibrations about the atomic positions of equilibrium, the subject has to be viewed in the light of the fundamental principles of thermodynamics and the quantum theory. However, as in the parallel problem of the vibration spectra of molecules, we have to seek the aid of classical mechanics for ascertaining the modes and frequencies of vibration with which we are concerned.

2. THERMODYNAMIC CONSIDERATIONS

Every crystal is a three-dimensional grouping in space of atoms held together by their mutual interactions; equivalent atoms

* "The Nature of the Thermal Agitation in Crystals," by Sir C. V. Raman, Memoir No. 77 from the Raman Research Institute, Bangalore, and *Proc. Ind. Acad. Sci., 1955, 42, 163-74.*

in the crystal are located at the points of a Bravais lattice, and if the crystal consists of p interpenetrating Bravais lattices, there would be p atoms in each unit cell of the crystal structure. Since the frequencies of vibration of the atoms are determined by their masses and by the interatomic forces which are of limited range, they would necessarily be the same for the group of atoms contained in every cell of the structure. Hence every crystal may be considered as an assembly of a great number of oscillators physically similar to each other and having a set of vibration frequencies in common, and which since the oscillators can exchange energy with each other, constitute a system in thermodynamic equilibrium. Each oscillator can for any particular frequency of vibration assume any of the energy states permitted by the quantum theory, the probability of its being present in any one state being given by Boltzmann's well-known formula. The energy of the entire assembly of oscillators can therefore be evaluated by multiplying the number of oscillators of any particular frequency by the average energy of an oscillator of that frequency which is calculable from the relative probabilities of its different energy states, and then summing up the results for all the frequencies. The total number of oscillators included in such a reckoning would be three times the number of atoms comprising the crystal. This follows from the theorem in classical mechanics which states that the number of normal modes of vibration of a connected system of particles is the same as the number of degrees of freedom of movement of the entire system.

3. DYNAMICAL THEORY

The dynamics of atomic vibration in a crystal may be dealt with from two different standpoints which may be designated as the "molecular" and "molar" points of view respectively. In the "molecular" approach to the problem, we fix our attention on a particular unit cell of the crystal structure and

proceed to write down and solve the $3p$ equations of motion of the p atoms contained in it, with a view to discover and enumerate their normal modes of vibration. In doing this we have necessarily to take account of the forces arising from the movements of the atoms in the surrounding cells which interact with those in the cell under consideration. It is obvious that no mode of vibration of the atoms in the unit cell can persist unchanged unless the atoms in the surrounding cells also vibrate in a similar mode with the same frequency. This would be the case if equivalent atoms in these outer cells also vibrate with the same amplitudes, but as regards their phases of vibration, there are several distinct possibilities. A formal investigation shows that there are $2 \times 2 \times 2$ or eight possibilities in all which can be described as follows: The phases of equivalent atoms are either the same or else opposite in consecutive cells along one, or two, or all the three axes of the Bravais lattice. The identity of the amplitude of vibration of equivalent atoms reduces the number of independent co-ordinates to $3p$ only. Thus, the equations can be solved and result in $3p$ solutions, but as there are eight different situations in respect of the phases, we have $8 \times 3p = 24p$ solutions in all. This is the same as the number of degrees of dynamic freedom of the $8p$ atoms contained in a super-cell having twice the linear dimensions of the unit cell of the crystal structure. Accordingly, we recognize $(24p - 3)$ normal modes of vibration properly so-called, the three omitted degrees of freedom representing the translatory movements of the super-cell.

In the "molar" approach to the problem, we consider the entire crystal as a single physical entity and investigate the propagation of waves through its structure. The wave equations are found to be formally satisfied if it be assumed that the equivalent atoms located at the points of a Bravais lattice have the same amplitude of vibration,

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this however being different for the different lattices of atoms, while the frequency, wave-length and the direction of the wave-vector are the same for all the interpenetrating lattices. Proceeding to solve the set of $3p$ equations obtained on this basis, an algebraic equation of degree $3p$ for the frequency results, and the solution of this gives us $3p$ different frequencies for a wave of given wave-length travelling in any assigned direction. By considering the functional dependence of these $3p$ frequencies on the wave-length and direction of propagation, it is found that the group-velocity of the waves vanishes for $(24p - 3)$ frequencies associated with eight different wave-vectors in the crystal. The $(24p - 3)$ frequencies thus obtained and the corresponding modes of vibration are found to be the same as the frequencies and normal modes deduced by the "molecular" approach to the problem, namely, those in which equivalent atoms in consecutive cells vibrate with the same amplitude and with phases that are either the same or else opposite along one, two or all three of the Bravais axes of the crystal. They may therefore be identified as the characteristic or normal modes and frequencies of vibration of the crystal structure. The three omitted frequencies represent the limiting case of the three sets of waves of the lowest frequencies and the longest wavelengths for which the group velocity does not vanish but comes out as equal to the phase-velocity of the waves. These cases are identifiable with the three types of waves whose propagation in any direction in the crystal is shown to be possible by the classical theory of elasticity. The vanishing of the group velocity for all the $(24p - 3)$ frequencies characteristic of the lattice structure is significant. It indicates that no wave-propagation in any real or physical sense is possible in a crystal except in the lowest range of frequencies where alone the ideas and results of the classical theory of elasticity possess any validity.

4. THE SPECTRUM OF THE THERMAL AGITATION

The results of the dynamical theory enable us to complete the thermodynamic picture already indicated above in outline. The p interpenetrating Bravais lattices of atoms constituting the crystal represent an assembly of atomic oscillators which have a set of $(24p - 3)$ vibration frequencies in common. Each of these oscillators can assume one or another of the various energy states for these frequencies permitted by the quantum theory, the relative probabilities of the same being given by the Boltzmann formula. It would not be possible to specify or predict which of the great number of oscillators in the crystal would be in a particular excited state for any of its possible frequencies of vibration at any given instant. In other words, the thermal energy would be distributed through the volume of the crystal in a manner which fluctuates from place to place and from instant to instant in an unpredictable fashion. The fluctuating character of the energy distribution would be the more striking, the higher the frequency under consideration, since the energy jumps indicated by the quantum theory are proportional to the frequency.

Thus, it emerges that $(24p - 3)$ out of every $24p$ degrees of freedom of atomic movement in the crystal manifest themselves in the thermal agitation as modes of internal vibration with a precisely defined set of monochromatic frequencies and in modes specifically related to the crystal structure, though they are localised in the crystal in a chaotic and unpredictable fashion. The residual 3 degrees out of every $24p$ degrees of freedom represent, as we have seen, the translatory movements of the super-cells of the crystal lattice. Such movements would disturb the regularity of the crystal structure, in other words, would give rise to stresses and strains of the same general nature as those contemplated in the classical theory of elasticity. Hence, the 3 residual

degrees of freedom would also manifest themselves in the thermal agitation as oscillations localised in the crystal in a chaotic and unpredictable fashion, but since the moving masses are now larger, the frequencies would necessarily be lower, being determined by the dimensions of the volume elements which can be regarded as the individual oscillators: the larger these volume elements are, the fewer of them would be needed to fill the crystal and the lower also would be the frequency. Thus, the spectrum of the thermal agitation resulting from movements of the kind under consideration would stretch over a range of frequencies down to low values, but the upper parts of the range would be much more densely populated than the lower.

5. REMARKS ON SOME EARLIER THEORIES

The attentive reader would have noticed that the picture of the thermal agitation in a crystal and its spectroscopic characters which has emerged bears no resemblance whatever to that figuring in the well-known theory of the specific heat of crystals put forward by Debye and in the lattice theory of Max Born and his collaborators. These authors identify the energy of the thermal agitation in a crystal with the energy of an immense number of waves traversing the crystal in all possible directions and of which the frequencies are all different. But nevertheless in evaluating the total energy, these authors make use of the expression for the average energy of an oscillator derived by Einstein for an assembly consisting of an immense number of oscillators having an identical frequency of vibration. In the circumstances, it would not be superfluous to set out briefly the considerations which show that the theories of Debye and Born are fundamentally misconceived and that the conclusions to which they lead are completely unreal.

I. The theory of the specific heat of crystals has necessarily to be based on the

theorem in classical mechanics which states that the normal modes of vibration of a connected system of particles form an enumerable set equal in number to the number of degrees of dynamical freedom of the system and that in each such normal mode, all the particles vibrate with the same or opposite phases. Waves are not normal modes, since the phase alters progressively in the direction of the wave-vector, and hence it is an obviously fallacious procedure to seek to found a theory of specific heat on the basis of wave-motions.

II. A dynamical investigation shows that waves of the kind contemplated by the classical theory of elasticity in which the phase-velocity is equal to the group velocity are only possible in the limiting case of very low frequencies and of very great wavelengths. It also shows that the atoms in a crystal form an assembly of oscillators which have a set of $(24 p - 3)$ vibration frequencies common to all, and hence form a system to which the principle of Boltzmann can be legitimately applied to determine the average energy of an oscillator of each frequency and thereby to evaluate the total energy of the system.

III. The fundamental principles of thermodynamics and the quantum theory indicate that the thermal agitation in a medium consisting of material particles capable of vibrating about their positions of equilibrium is of a chaotic and unpredictable character, exhibiting fluctuations in the energy of the vibration from place to place and from instant to instant whose magnitude is determined by the frequency of vibration and hence would be different for each different frequency. It would be patently absurd to identify such a disturbance in the crystal with waves of constant amplitude spread over its volume.

IV. The identification of the thermal energy of a crystal with the energy of waves traversing it in all directions and having

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frequencies all different from each other leads to a totally false picture of the spectroscopic behaviour of crystals, as is shown by several independent methods of experimental investigation. For instance, all crystals usually exhibit at room temperature and always when cooled down to low temperatures the sharply defined shifts of frequency in the spectrum of monochromatic light scattered by them, corresponding to each of the (3 p - 3) frequencies of the structure active in light-scattering. Significantly also, overtones and combinations of

these (3 p - 3) frequencies and of the remaining 21 p frequencies manifest themselves with observable intensity as sharply defined frequency shifts with many crystals.

V. That the identification of the thermal agitation in a crystal with waves traversing the solid is a misconceived idea is also apparent from the complete dissimilarity between heat energy and sound energy in their observable behaviour. The latter travels through a crystal with a velocity of some thousands of metres per second, while heat energy merely diffuses through it.

NOBEL PRIZE FOR PHYSICS, 1955

THE Nobel Prize for Physics has been awarded this year jointly to Prof. W. E. Lamb and Prof. P. Kusch, for studies on the hyperfine structure of hydrogen and other atoms in the radio-frequency region and the precision determination of the magnetic moment of the electron, carried out at the Columbia University, New York.

These studies were initiated by Lamb soon after the close of the war in 1945, utilising the various new techniques developed during the war in the production and measurement of microwaves. It is known that the level $n = 2$ of the hydrogen atom has three quantum states 2S_1 , 2P_1 and $^2P_{3/2}$. The Dirac theory of the electron requires that the first two of these must correspond to the same energy, while the third, $^2P_{3/2}$, will be different. However, a careful study of the fine-structure of the H_α line ($n = 3$ to $n = 2$) indicated that the former two may not be identical. Theoretically, such a difference would be expected owing to the interaction of the electron with the electromagnetic field, the so-called radiative correction. Another consequence of this would be that the magnetic moment of the electron due to its spin will differ from its classical value by a small amount of the order of $1 \cdot 1 \times 10^{-8}$.

The H_α fine structure measurements could not give an accurate value of the $^2S_1 - ^2P_1$ separation. In 1947, Lamb and Rutherford measured this separation by obtaining metastable atoms of hydrogen in the 2S_1 state and directly inducing transitions in them to the 2P_1 state by means of microwave radiations of the appro-

priate frequency. They obtained a value $1,062 \pm 5$ MC/S with both hydrogen and deuterium.

Kusch and collaborators continued these experiments with various elements, and they were able to show definitely the existence of an anomalous electron spin magnetic moment. In 1952, they made a carefully planned series of experiments to measure this with great precision and obtained a value $g_e/g_p = 658 \cdot 2288 \pm 0 \cdot 0006$ for the ratio of the g values of the free electron spin and of the proton. Earlier measurements of Purcell (Nobel Prize winner for 1952) and collaborators had yielded a value $657 \cdot 475 \pm 0 \cdot 008$ for the ratio $2g_e/g_p$, where g_e is the electron orbital g value. Combining the two, the magnetic moment of the electron was calculated to be $1 \cdot 001146$ times the value given by the Dirac theory, in almost perfect agreement with the value $1 \cdot 0011454$ calculated from theory to the fourth order approximation.

The precise studies of Lamb, Kusch and their collaborators have led to valuable data which have helped in giving confidence to the quantum electrodynamists that the rather revolutionary ideas of re-normalisation which they have introduced in their theories are in the right lines.

Prof. Lamb, who is 42, is Professor of Physics of the Stanford University, California, since 1951. Prof. Kusch (44) was associated with research at Columbia University during the war and afterwards joined the Bell Telephone Laboratories. He is now a Professor at Columbia University, New York.

INFLUENCE OF TOTAL BODY X-RAY IRRADIATION ON METHIONINE AND CHOLINE LEVELS IN RAT LIVERS

U. S. KUMTA, S. U. GURNANI AND M. B. SAHASRABUDHE

Biology Division, Dept. of Atomic Energy, Indian Cancer Research Centre, Bombay-12

ONE of the earliest events in the sequence of reactions, that result after radiation exposures, is the formation of free radicals like H, OH, HO₂, etc.^{1,2} These radicals being very reactive and consequently of a very unstable nature combine with some of the essential metabolites of the system and thus bring about radiation damages like lowering of RBC and WBC counts, inducing haemorrhages, etc., by blocking one system or another. Among the many compounds that are normally present in the metabolic pool, SH compounds appear to be more sensitive to the action of the free-radicals. Various SH containing compounds such as cysteine, BAL, thiourea, glutathione, etc., have therefore been tried therapeutically to counteract the radiation damages without much success.³⁻⁵ Apparently the changes in the metabolic pool are of such a nature that they cannot be reversed by any of the SH containing compounds tested so far. Experiments with micro-organisms^{6,7} tissues,⁷ animals,^{8,9} etc., have shown that these compounds do show some amount of protection if administered prior to radiation.⁹ This probably implies that the added compounds successfully compete with substances in the metabolic pool in their avidity for combination with free radicals.

Although quite a large amount of information is available about the lability of SH containing compounds to radiation exposures,¹⁰⁻¹⁵ very little appears to be known about the fate of other sulphur containing metabolites in the body. Methionine which contains a S-CH₃ group calls for special attention for two reasons: (i) it is an essential amino acid, and (ii) it takes part in the biological transfer of methyl groups. Experiments have therefore been carried out to study the effect of total body irradiation on the levels of methionine in rat livers. Since choline is one of the first products formed as a result of transfer of methyl group, levels of choline have also been studied in irradiated animals and are reported in this communication.

EXPERIMENTAL

Wister rats, 2½-3 months old, weighing between 200-250 g., have been used in the present investigation. The animals were irradiated with X-rays using 230 KV Westinghouse machine with 1 mm. Al and 0.5 mm. cu. filters. Whole

body irradiation of 600 r (L.D. 50 for rats in 30 days) was given at a rate of 50 r per minute by exposing the dorsal and ventral sides to 300 r each. Methionine levels were studied at 24 hours after irradiation whereas choline levels were determined at 24 and 48 hours after irradiation. Independent sets of experiments were carried out for studying the levels of methionine and choline. All the animals, controls as well as experimental, were fasted for 24 hours before sacrifice. Animals were killed by dislocation of the cervical vertebrae, and the livers were immediately dissected out and processed for the assay of methionine or choline as the case may be.

For the estimations of methionine, the livers were homogenised in 0.013 N acetic acid and the homogenate boiled for a couple of minutes. This procedure extracts the free amino acids and at the same time coagulates the tissue proteins, which are subsequently removed by filtration. The filtrates are further deproteinised by adding 1 ml. of 10% tungstic acid per 5 g. of tissue taken according to the method of Solomon et al.¹⁶ for the estimation of free amino acids. The deproteinised filtrate is adjusted to pH 6.8 and aliquots taken for the microbiological assay of methionine using the organism *Leuconostoc mesenteroides* P-60.¹⁷

For the assay of choline the micromethod of Erickson et al.¹⁸ was followed. The liver tissue is extracted with CH₃OH : CHCl₃ (1 : 1) and the extract is concentrated on a water-bath. The residue is hydrolysed with 5 ml. of saturated Ba(OH)₂ and then neutralised with 10% HCl and filtered. Suitable aliquots of the filtrate are treated with iodine-iodide reagent in cold to precipitate choline as its enneaiodide. The precipitate is oxidised by bromine in acetate solution and the iodate thus formed is directly titrated against standard sodium thiosulphate.

The results are given in Table I.

It will be seen from the table that methionine levels drop to 25% of the levels in control animals at 24 hours after irradiation. Choline levels on the other hand drop to 66 and 57% of the control values at 24 and 48 hours after irradiation respectively. This clearly shows that methionine containing an active

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The Anti-Proton

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S-methyl group is very radio-labile and our unpublished results (not included here) further suggest that the cleavage is probably taking place at S-C linkages.

TABLE I

Effect of total body irradiation (600 r) on free-methionine and choline levels in rat livers at 24 and 48 hours after irradiation

Group	Amount of methionine μg/g. of liver	Amount of choline mg./g. of liver
Control	.. 86.16 ± 5.83 (10)	9.31 ± 0.064 (4)
24 hr. after irradiation	18.75 ± 0.79 (11)	6.22 ± 0.26 (4)
48 hr. after irradiation	..	5.44 ± 0.19 (4)

Figures in parenthesis indicate the number of animals used. The standard errors have been calculated using the formula $[\sum d^2 / n(n-1)]^{1/2}$.

Grateful thanks are due to Dr. V. R. Khanolkar and Dr. A. R. Gopal Ayengar for helpful suggestions and criticisms, and to Drs. Mody and Vohra of Tata Memorial Hospital and Dr. M. S. Waravdekar of Bombay Hospital for

providing the facilities of irradiating the animals.

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THE ANTI-PROTON

THE Atomic Energy Commission and the University of California have jointly announced the discovery of a new atomic particle, the anti-proton, which may open the way to a fuller understanding of basic nuclear processes.

The anti-proton, or negative proton, is not a part of the atomic nucleus, which consists of only protons and neutrons, but is created after some event such as a high energy collision of nuclear particles. The main reason why the anti-proton was not discovered earlier is that it occurs only at high energy, and until the construction of the great "bevatron" on the University of California's campus at Berkeley it was impossible to create nuclear bombardments of sufficient energy.

The "bevatron", which was built and operated by the A.E.C. enabled protons to be accelerated to 60,000 million electron volts, at which point they were directed at a target of copper inside the "bevatron" chamber. The collision of one of the protons with a neutron of copper produced not only the original proton and neu-

tron but also a new set of heavy particles—another proton, and an anti-proton. In the collision, a part of the bombarding proton energy is converted into mass, according to Einstein's theory.

In a vacuum the anti-proton is stable and will not disappear spontaneously, but in contact with a proton both particles immediately decay into mesons and disappear; this has led some reports to describe the anti-proton as the "annihilator of matter". To identify the anti-proton a "maze" was devised through which only anti-protons could pass.

The term "reverse matter", which has also been used in some reports, is a reference to the further speculation that elsewhere in the universe there might exist matter in which all the protons were negative and all the electrons positive—a sort of "looking glass" world. The discovery confirms earlier reports by Dr. M. Schein of Chicago University and Professor Bruno Rossi of the Massachusetts Institute of Technology, who, however, had less satisfactory evidence.

A NEW EQUATION FOR THE OXYGEN DISSOCIATION CURVE OF BLOOD

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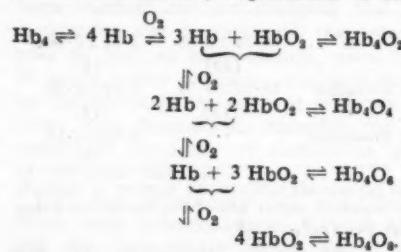
OXYGEN dissociation curves of blood have attracted the attention of many physiologists and physical chemists for well over forty years. It is well known that in case of pure dialysed haemoglobin, the curve assumes the shape of a simple Langmuir adsorption isotherm, while in the case of blood, a number of S-shaped curves are obtained under various conditions. The percentage oxygen absorption by blood decreases with (a) a decrease in the pH (i.e., an increase in eH^+), (b) an increase in the mineral salt concentration, or (c) an increase in the carbon dioxide tension.² Many attempts have so far been made to explain this phenomenon and also to derive a suitable equation for these curves, especially by Hill,³ Adair⁴ and by L. Pauling⁵ besides several others. Hill's equation was discarded as empirical and unsatisfactory.⁶ Many of the other equations are based on assumptions and hypotheses of very advanced nature and are rather complicated, involving a number of constants. Further, these equations govern only one or two aspects of the problem and are not very satisfactory at the extreme oxygen tensions. Thus, a simple and comprehensive equation, covering all the influencing factors, does not seem to have been worked out yet.

A reinvestigation of the problem, based on elementary physico-chemical principles, has therefore been taken up by the present author. This investigation is based on two postulates, evidence in support of which can be cited from the more recent work on haemoglobin.

(i) It is the haemoglobinate ion that takes up oxygen and not the unionised haemoglobin molecule as was assumed by the previous investigators. This is supported by the fact that about 65% of the haemoglobin in blood exists as the potassium salt and only 35% as free haemoglobin. Instances can be cited where such organic ions (though less complex ones) take up oxygen in alkaline media. Further, this postulate explains the increased oxygen absorption with increased alkalinity (pH) of blood, as also the influence of mineral salts.

(ii) Osmotic pressure determinations of haemoglobin by Gutfreund⁷ show evidence in favour of its dissociation, though only to a slight extent. It is therefore postulated that in blood, Hb_4 exists in a dissociation equilibrium with Hb and that it is the Hb that actually combines

with oxygen giving HbO_2 and not Hb_4 . A number of molecules of this HbO_2 may then combine (or associate) with a suitable number of Hb molecules to give the various "intermediate compounds" of Pauling, Roughton and others, viz., Hb_4O_2 , Hb_4O_4 , Hb_4O_6 and Hb_4O_8 . This can be schematically represented as follows:



Thus, the intermediate compound hypothesis of oxyhaemoglobin fits well into the above scheme.

Starting from these postulates and applying the Law of Mass Action to the haemoglobin-oxygen reaction under various conditions, the following equations have been derived for the various curves.

i) $Y = 100K_1p / (1 + K_1p)$
for pure dialysed haemoglobin, which is identical with the Hill's first equation.

ii) $Y = (100 - S) e^h \cdot \frac{K_1p}{1 + K_1p}$

for blood under the influence of pH and in presence of mineral salts.

iii) $Y = \frac{100 K_1 p}{(1+K_1 p)} \cdot \frac{(1+p)}{(1+p+K_2 p')}$

for blood at a carbon dioxide tension p' .

It can also be shown that these three equations are only the particular solutions of a more general equation given below, governing all the influencing factors, viz., the presence of mineral salts, pH and the presence of carbon dioxide.

iv) $Y = (100 - S) e^h \cdot \frac{K_1 p}{(1+K_1 p)} \cdot \frac{(1+p)}{(1+p+K_2 p')}$

where Y is the observed oxygen absorption by blood or by pure dialysed Hb , S is a factor proportional to the mineral salt concentration, $h = (pH - pK)$ or $(eK - eH)$, p is the oxygen tension at equilibrium with blood, p' is the carbon dioxide tension at equilibrium with blood, and K_1 and K_2 are constants.

This equation has the unique advantage of governing all the factors influencing the

absorption of oxygen by blood. It involves only two constants and is much simpler than some of the previous equations containing as many as four constants. It is significant, as has been found, that most of the observed data for the oxygen absorption by blood under various physiological conditions fit into this equation in a very satisfactory manner.

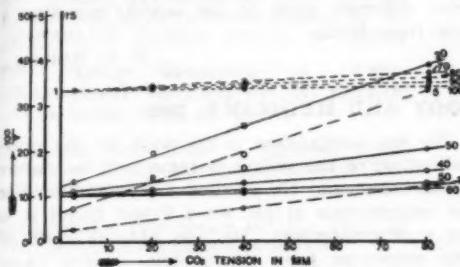


FIG. 1. The oxygen tension for each curve is marked at the end of the curve. The scale for $100/Y$ for tensions between 0 and 10 mm. is reduced 10 times to bring the curves within the size of the figure. The scale for $100/Y$ for tensions 70 mm. to 100 mm. is increased 10/3 times, to show them clearly without overlapping.

Thus, for instance, for a particular specimen of blood (i.e., $h = \text{constant}$ and $S = \text{constant}$ in the above equation) and at a definite oxygen tension (i.e., $p = \text{constant}$), equation (iv) can be directly transposed into the following equation, giving a linear relation between the carbon dioxide tension and the reciprocal of the oxygen absorption :

$$100/Y = \alpha + \beta p'$$

where, α and β are constants for a given oxygen

tension, i.e., Equation (iv) predicts that if $100/Y$ be plotted as ordinate against the corresponding p' as abscissæ at any constant oxygen tension, a straight line should be obtained for each oxygen tension. When the reciprocals of $Y/100$ (i.e., of percentage oxygen absorption) from Henderson's *et al.*⁸ data are plotted against the corresponding carbon dioxide tensions (p'), it is found that the resulting points strictly lie in one straight line for each oxygen tension. The graphs are given in Fig. 1. This striking agreement between the predicted and the observed results not only proves beyond doubt the validity of the present equation, but it also shows that this equation holds good for the whole of the observed range of oxygen and carbon dioxide tensions, while the previous equations were reported to have proved less satisfactory at extreme oxygen tensions.⁹

Full details will be published elsewhere. The author thanks Dr. A. A. Aiyar of Stanley Medical College, and Prof. K. S. Srinivasa Varadan of the Madras Medical College, Madras, for their interest.

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NOBEL PRIZE FOR CHEMISTRY, 1955

THE Nobel Prize for Chemistry has been awarded to Prof. Vincent du Vigneaud, Professor of Biochemistry, Cornell University Medical College, New York. In announcing the award, the Swedish Academy of Sciences mentioned Prof. du Vigneaud's researches on biochemically important sulphur compounds, especially the first synthesis of a hormone which plays a significant role in the regulation of life processes.

Prof. du Vigneaud has carried out extensive research work on the chemistry of a number of complex substances of biological origin. In his book entitled *A Trail of Research in Sulfur Chemistry and Metabolism and Related Fields*, published in 1952, he has presented a very beautiful account of the biochemical research work carried out by him originating from

a study of the chemistry of insulin and dealing with the conversion of methionine and homocystine to cystine, the participation of choline, betaine and related compounds in the process of transmethylation and the biosynthesis of 'labile' methyl groups. He has also collaborated during World War II with a number of scientists both in U.K. and U.S.A., in the study of the structure and later the synthesis of penicillin. His most important single piece of research, however, has been the working out of the structure of two hormones produced by the posterior lobe of the pituitary gland, and later their synthesis. These two hormones are built up of the same components, viz., amino acids, as are the proteins. But though the number of these amino acids in these hormones is relatively small in comparison to

proteins—8 in each case—their arrangement includes a ring structure, which makes their synthesis difficult. One of them, oxytocin, makes the uterus contract in childbirth while the other, vasopressin, constricts the blood vessels and increases the re-absorption of water by the tubules of the kidney. They were, the first hormones of their kind to be synthesised. A further point of interest was that there were minor differences according to the animal by which the hormone was produced.

Prof. du Vigneaud has been Professor and Head of the Biochemistry Department in Cornell University Medical College since 1938. He has won a number of American awards for research including the award of merit for war research. He has, in addition, a large number of research publications to his credit and among his collaborators may be counted many scientists from different parts of the world, including a few from India.

P. S. SARMA.

NOBEL PRIZE FOR PHYSIOLOGY AND MEDICINE, 1955

THE Nobel Prize for Physiology and Medicine for 1955 has been awarded to the Swedish Biochemist, Prof. Axel Hugo Teodor Theorell for his pioneering work on the mechanism of cell respiration and on enzymes associated with biological oxidations.

Prof. Theorell who was born on July 6, 1903, was educated at the Karolinska Institute, Stockholm. After taking the M.D. Degree in 1930, he continued as a Docent in the Karolinska Institute until 1932 in which year he joined the Kaiser Wilhelm Institute for Cell Physiology as Rockefeller Foundation Fellow to work under the celebrated biochemist, Prof. Warburg. He soon showed himself to be a man of exceptional ability and his stay there was liberally punctuated with brilliant discoveries. Since 1937, he has been Professor of Biochemistry and Head of the Medical Nobel Institute, Stockholm.

It has long been recognised that the fundamental problem in cell respiration (i.e., the utilization of molecular oxygen by the cell for the oxidation of organic metabolites) is the elucidation of the nature and mode of action of the catalytic systems on the presence of which the respiratory process is dependent. The epoch-making studies of Keilin, Warburg and others have brought to light the importance of carrier substances like cytochrome c and Warburg's flavoprotein in cell respiration. Prof. Theorell's early work was chiefly concerned with the establishment of the structure of cytochrome c and the crystallization of Warburg's 'old' yellow enzyme.

Pure cytochrome c was isolated for the first time by Prof. Theorell and his contributions to the problem of the constitution of cytochrome c represent a landmark in the chequered history of biochemistry as a separate discipline. Prof. Theorell found that in cytochrome c the haematin residue is united to the protein by means of thio-ether bindings of the haematin and also by 2-histidine imidazole groups.

No less outstanding is his work on the crystallization of the yellow enzyme and the nature of its coenzyme. He purified the yellow enzyme by cataphoresis at pH 4.2-4.5 and found it to be a chromoprotein. He was able to split off the coenzyme from the protein moiety (apo-enzyme) by dialysis against dilute hydrochloric acid at 0-2° C. He succeeded in preparing the coloured prosthetic group in crystalline form as the calcium salt and identified it as the monophosphoric acid ester of riboflavin. This experiment noted for its classical simplicity, revolutionized the concept of coenzymes in general and had a profound influence on subsequent biochemical research.

Prof. Theorell has also made important contributions on the nature of action of catalase and in the crystallization of horse-radish peroxidase and lacto-peroxidase. His extensive studies on the physical properties and chemical nature of the hydroperoxidases represent the spearhead of present research and has paved the way for launching studies of their enzyme-substrate compounds. The recent work of Prof. Theorell on these enzymes has a distinct physico-chemical bias and his magnetic susceptibility studies of the alkaline forms of horse-radish peroxidase, ferrimyoglobin and ferrihemoglobin indicate the non-identity of the electronic structure of these substances.

Besides this, Prof. Theorell has been responsible for the preparation of a crystalline lipoxidase from soya beans and in the development of a spectrophotometric method for the assay of lipoxidase.

His interest in the problem of cell respiration and other cognate fields has continued with unabated vigour and it is no exaggeration to state that his scientific career has throughout been a catalogue of brilliant researches and notable achievements.

K. V. GIRI.
C. S. VAIDYANATHAN.

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THE ELASTIC SCATTERING OF HIGH ENERGY ELECTRONS BY BERYLLIUM

THE nuclear scattering of 125 Mev electrons by beryllium has been observed by Hofstadter, Fecheter and McIntyre¹ who have attempted to correlate the same on the basis of various assumed nuclear charge density distributions. Schiff² has also carried out a similar analysis. Gatha, Patel and Patel³ have dealt with this experimental data on the basis of a nuclear density distribution determined by Gatha, Shah and Patel.⁴ Recently, McIntyre, Hahn and Hofstadter⁵ have observed the nuclear scattering of 190 Mev electrons by beryllium. In the meanwhile, Gatha and Shah⁶ have improved upon their previous analysis of the experimental data on the nuclear scattering of 340 Mev

protons and obtained an improved characteristic nuclear density distribution given by

$$\rho(\tilde{r}) = a_1 \exp(-b_1 \tilde{r}^2) + a_2 \exp(-b_2 \tilde{r}^2) - (1 - b_3 \tilde{r}^2 + b_4 \tilde{r}^4) \quad (1)$$

where,

$a_1 = 0.12 \times 10^{39}$ cm.⁻³, $a_2 = 0.25 \times 10^{39}$ cm.⁻³,
 $b_1 = 8.62 \times 10^{38}$ cm.⁻², $b_2 = 1.09 \times 10^{38}$ cm.⁻²,
 $b_3 = 0.44 \times 10^{38}$ cm.⁻⁴, $b_4 = 0.13 \times 10^{38}$ cm.⁻⁴,
while $\tilde{r} = rA^{-\frac{1}{3}}$, where A is the nuclear mass number. In the present investigation, the above experimental data on nuclear scattering of 125 Mev and 190 Mev electrons by beryllium have been analysed on the basis of the above characteristic nuclear density distribution.

The Born approximation can be taken to be reasonably valid in treating the nuclear scattering of high energy electrons by light nuclei.

In this approximation, the scattering cross-section is given by

$$\sigma(s) = (1 - \beta^2 s^2 / 4k^2) |f(s)|^2 \quad (2)$$

where

$$sf(s) = - \int_0^\infty U(r) \sin(sr) r dr \quad (3)$$

with

$\beta = v/c$, $s = 2k \sin(\theta/2)$, $U(r) = 2 \text{ EV}(r)/(hc)^2$. Following Mathur and Gatha,⁷ one can express the scattering amplitude in terms of the nuclear density distribution. For a characteristic nuclear density distribution, one can introduce the form-factor $g(\bar{s})$ as

$$\bar{s}g(\bar{s}) = \int_0^\infty \rho(\bar{r}) \sin(\bar{s}\bar{r}) \bar{r} d\bar{r} \quad (4)$$

where $\bar{s} = sA^{1/3}$. The form-factor is then related to the cross-section as

$$\sigma(\bar{s}) = \left(1 - \frac{\beta^2 s^2}{4k^2 A^{2/3}}\right) \left\{ \frac{8\pi E Z e^2 A^{2/3}}{(hc)^2 \bar{s}^2} g(\bar{s}) \right\}^2 \quad (5)$$

Substituting in equation (4), the expression for $\rho(\bar{r})$ from equation (1), one obtains

$$g(\bar{s}) = a_1 \exp(-\beta_1 \bar{s}^2) + a_2 \exp(-\beta_2 \bar{s}^2) / (1 - \beta_3 \bar{s}^2 + \beta_4 \bar{s}^4) \quad (6)$$

where

$$a_1 = 0.022 \text{ mb.}, \quad a_2 = 0.0078 \text{ mb.}$$

$$\beta_1 = 0.29 \times 10^{-26} \text{ cm.}^2, \quad \beta_2 = 0.23 \times 10^{-26} \text{ cm.}^2$$

$$\beta_3 = 0.04 \times 10^{-26} \text{ cm.}^2, \quad \beta_4 = 0.0075 \times 10^{-22} \text{ cm.}^4$$

The theoretical form factor $g(\bar{s})$, calculated from equation (6) is shown in Fig. 1. The experimental form factors, both for 125 Mev and 190 Mev were calculated from the given

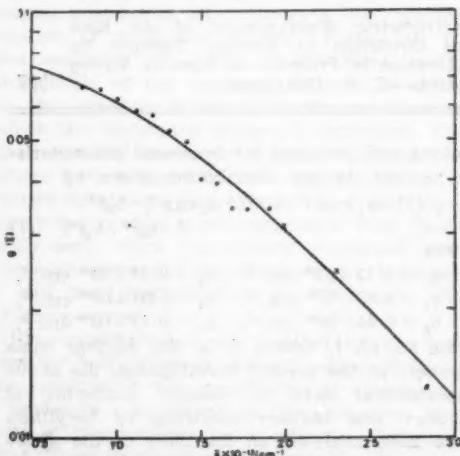


FIG. 1. The full curve represents the theoretical form-factor, while the dots and crosses represent the experimental form-factors for 125 Mev and 190 Mev respectively.

experimental values of $\sigma(\bar{s})$ by using equation (5). Since the measured values of $\sigma(\bar{s})$ are only relative values, the experimental form-factors for each energy have been multiplied by an appropriate constant to bring it in agreement with the theoretical form factor. It turns out that the measured cross-sections have to be multiplied by 0.00058 mb at 125 Mev and by 0.0010 mb at 190 Mev to convert them into absolute cross-sections. It is clear from Fig. 1 that there is a reasonable agreement between the theoretical and the experimental form factors.

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Mayo Road, Bombay-1, K. M. GATHA.
September 15, 1955.

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THE NUCLEAR SCATTERING OF 14 MEV NEUTRONS

AMALDI, BOCCIARELLI, CACCIAPUOTI AND TRABACCHI¹ have observed the nuclear scattering of 14 Mev neutrons. They have measured the total scattering cross-sections for various nuclei from which they have calculated the nuclear radii, on the basis of an opaque nuclear model, by using the approximate expression :

$$\sigma_t = 2\pi R^2 \quad (1)$$

where σ_t = total scattering cross-section, and R = the nuclear radius.

These nuclear radii were found to obey the relation :

$$R = (R_0 + \bar{R} A^{1/3}) \quad (2)$$

where

$$R_0 = (1.5 \text{ to } 2.0) \times 10^{-13} \text{ cm.}$$

$$\bar{R} = (1.0 \text{ to } 1.3) \times 10^{-13} \text{ cm.}$$

A subsequent analysis of the same data by Fernbach² led to $R_0 = 1.22 \times 10^{-13} \text{ cm.}$ and $\bar{R} = 1.37 \times 10^{-13} \text{ cm.}$ It is interesting to note here that an analysis with the same order of approximation, of the experimental data, on the nuclear scattering of 90 Mev neutrons on the basis of a transparent nuclear model, by

equation (3) leads to $R_0 = 0$. Thus it is unlikely that the intercept R_0 is an inherent property of the nuclear radius. Attempts have been made to relate R_0 with the wave-length of the incident particle as described by Mott and Massey.⁴ These indicate that R_0 arises as a result of using the approximate expression given in equation (1), for the nuclear scattering of 14 Mev neutrons.

The nuclear radii have been calculated in the present investigation, from the experimental data of Amaldi et al.,¹ by using the exact expression

$$R_0 = \frac{4\pi}{k^2} \sum_{l=0}^{\infty} \frac{(2l+1) j_l^2(kR)}{j_l^2(kR) + n_l^2(kR)} \quad (3)$$

where j_l and n_l are spherical Bessel functions of the first and second kinds respectively, while k is the magnitude of the propagation vector of the incident wave. A least square fit of equation (2) for the nuclear radii, presented by Amaldi et al.,¹ give $R_0 = (1.11 \pm 0.26) \times 10^{-13}$ cm. and $\bar{R} = 1.42 \times 10^{-13}$ cm. A similar calculation, using the nuclear radii obtained in the present investigation, leads to $R_0 = (0.57 \pm 0.26) \times 10^{-13}$ cm. and $\bar{R} = 1.32 \times 10^{-13}$ cm. The probable errors on \bar{R} are negligible in both these calculations. Repeating these calculations, while considering the probable errors on nuclear radii, leads to about the same values for R_0 and \bar{R} .

Thus it is clear that an exact analysis of the experimental data on the nuclear scattering of 14 Mev neutrons, on the basis of an opaque nuclear model significantly reduces the magnitude of R_0 . However, such a calculation does not make R_0 vanish completely. This may, perhaps, be due to some systematic error in the experimental data of Amaldi et al.¹ On the other hand, this may also indicate the inadequacy of the opaque nuclear model, with uniform density distribution, for correlating the experimental data on the nuclear scattering of 14 Mev neutrons.

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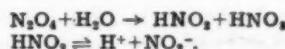
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ULTRASONIC RELAXATION IN AQUEOUS SOLUTIONS OF N_2O_4

ULTRASONIC absorption measurements in aqueous solutions of sulphur dioxide and sulphites have revealed the existence of a relaxation phenomenon.¹ The existence of this phenomenon in solution was ascribed to the disturbance in the chemical equilibrium between the sulphurous acid and its individual ions in solution in the presence of the ultrasonic beam. To prove this point further, the present work has been undertaken.

Nitrogen tetroxide gas has been thoroughly studied by Richards and Reid^{2,3} and it is known to exhibit a frequency of peak absorption in the region of 400 Kc/s as compared to about 1 Mc/s for SO_2 gas. In aqueous solution, N_2O_4 undergoes a chemical change and a dynamic equilibrium is set up as indicated by the equations⁴



On an analogy with SO_2 solutions, the aqueous solutions of N_2O_4 also must exhibit peaks of absorption but at a frequency lower than those of the former. The ultrasonic absorption is measured using the pulse technique of Pellam and Galt with the modification that a second crystal is used as receiver instead of a reflector. The temperature is held constant at 29° C. to within $\pm 0.5^\circ$ C. and attenuation measurements are accurate to within $\pm 5\%$.

The gas, prepared by the action of dilute HCl on sodium nitrate, is passed through water. The strengths of the solutions are determined by a standard method of titration. Only dilute solutions have been used in these experiments to ensure constancy of concentration during ultrasonic observation and also to avoid bubbles of gas forming within the liquid under ultrasonic excitation. A number of concentrations have been studied but only a representative set of results is given in Fig. 1.

From the figure, it will be seen that the results are very similar to those in sulphur dioxide. The frequency of peak absorption increases with increasing concentration upto a limit after which it becomes independent of concentration. As the observations are confined to the Fresnel region of the ultrasonic beam, frequencies below 2 Mc/s could not be employed.

Sodium nitrite solutions also exhibit this phenomenon confirming the fact that it is NO_2^- ion that is responsible for this effect.

Preliminary experiments dealing with the effect of temperature on the peak absorptior

frequency also confirm that there is a close relation between this frequency and the rate of chemical reaction going on in the solution.

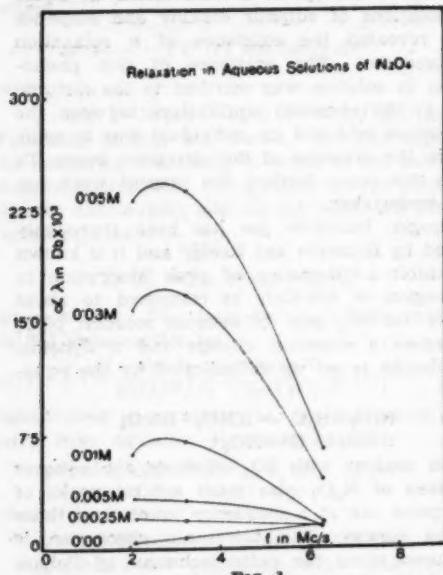


FIG. 1.
Fuller results of this work will be published separately.

The authors thank Professor S. Bhagavantam for his interest and guidance during the course of this work.

Physical Lab., M. KRISHNAMURTHI.
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CONFIGURATION INTERACTION IN H_2^+ STATE OF H_2 MOLECULE

THERE is a close analogy between the way in which appropriate H-atom-like wave functions can be used for building up wave functions for atomic He and the way in which H_2^+ -ion-like wave functions can be used for building up wave functions for molecular H_2 ; this analogy has been noted by Mulliken¹ who has suggested several lines of work regarding the computation of configuration interaction in H_2 molecule. A detailed calculation by Taylor and Parr² has exhibited the accuracy that can be

attained by a proper choice of H-like functions for treating configuration interaction in the case of atomic He.

No calculations of configuration interaction for molecular H_2 have been made so far, following the analogy noted above. A programme has been undertaken by the author to study configuration interaction in H_2 molecule, at various internuclear distances, using single electron wave functions which arise in the solution of the H_2^+ problem. The following is a preliminary notice of the computation made for the energy at the equilibrium nuclear distance, namely, 1.4 atomic units (a.u.). The energy which the author has calculated at 1.4 a.u. is lower than any other value reported so far. It is even lower than the value — 2.3154 a.u. which James and Coolidge³ have thought to be the best possible without the explicit introduction of the interelectronic distance in the wave function.

In terms of the usual confocal elliptical coordinates, the three configurations used were:

$$(1s\sigma)' : \psi_1 = e^{-\delta} (\xi_1 + \xi_2) \\ [1 + p (\xi_1 + \xi_2) + r \xi_1 \xi_2] (1 + c \eta_1^2) (1 + c \eta_2^2) \\ (2p\sigma)^2 : \psi_2 = e^{-\lambda} (\xi_1 + \xi_2) [\eta_1 \eta_2] \\ (2p\pi)^2 : \psi_3 = e^{-\mu} (\xi_1 + \xi_2) \\ [(t_1^2 - 1) (t_2^2 - 1) (1 - \eta_1^2) (1 - \eta_2^2)] \\ \cos (\phi_1 - \phi_2).$$

In the $(1s\sigma)$ $(1s\sigma)'$ configuration it was found more convenient to open out the shell by taking p and r as shown, rather than by taking two exponentials δ and λ ; for the sake of avoiding unduly elaborate computations, λ and μ were taken equal to $\delta = 0.75$, which is the James and Coolidge exponential at 1.4 a.u.

The results of the calculations with ψ_1 , ψ_2 and ψ_3 given above are as follows:

(i) Using ψ_1 only and taking $\delta = 0.75$, the energy was found to be minimum when $p = 0.01134$, $r = -0.03693$ and $c = 0.255$, the minimum value being — 2.2727 a.u.

(ii) Using ψ_1 , ψ_2 and ψ_3 , taking $\delta = \lambda = \mu = 0.75$, $p = 0.01134$, $r = -0.03693$ and $c = 0.255$, the minimum value of the energy is — 2.3180 a.u.

The value computed by James and Coolidge with their 13 term wave function is — 2.34705 a.u. Thus the correlation energy is more than halved in including the 'angular' configurations $(2p\sigma)^2$ and $(2p\pi)^2$ and a very close agreement with the actual energy has been obtained by taking one electron molecular orbital functions of the type $(1s\sigma)$, $(2p\sigma)$ and $(2p\pi)$. Of course a certain amount of advantage has been lost in taking $\delta = \lambda = \mu$ which means that

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the value — 2.3180 a.u. can be pushed further towards the best value of James and Coolidge.

Similar calculations at smaller internuclear distances are in progress and details will be published separately.

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Osmania University, Hyderabad-Dn.,
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INTRASTRATAL SOLUTIONS AND HEAVY MINERAL FREQUENCY IN SEDIMENTARY ROCKS

THE present paper details the results of study of heavy minerals in the sedimentary rocks of Nuzvid area (E. Long. $80^{\circ} 51' 30''$ and $81^{\circ} 0'$, N. Lat. $16^{\circ} 45'$ and $17^{\circ} 0'$). The geological formations are Rajahmundry sandstones, Gollapalli sandstones, Chintalapudi sandstones and Khondalites.

Five samples from the Chintalapudi stage, twelve from Gollapalli horizon and four from the Rajahmundry formation were studied for their heavy minerals, following the standard petrographic methods. Frequencies of the individual minerals after Evans, Hayman and Majeed¹ were calculated from the percentages. Table I gives the average composition of each stage on heavy mineral basis (magnetite-free).

TABLE I

	Chintalapudi	Gollapalli	Rajahmundry
Zircon (Yellow)	..	5	6
Zircon (Colourless)	..	7	7
Rutile	..	6	5
Staurolite	..	4	4
Sphene	..	4	..
Kyanite	..	2	6
Garnet	..	3	5
Hypersthene	..	1*	2
Sillimanite	5
Epidote	1

* Represents less than 0.5%.

A general study of the mineral assemblages of the three formations from the above table reveals two striking features: (1) there is an enrichment of heavy minerals in the younger formations; and (2) epidote and hypersthene, termed as comparatively unstable by Goldschmidt²

and Pettijohn³ are absent from the Chintalapudi stage, but are persistent in the Tertiary rocks. It is suggested that these phenomena are due to the effect of intra-stratal solutions, after Pettijohn,³ Boswell⁴ and Crook.⁵

The author is indebted to Prof. C. Mahadevan for helpful guidance and criticism.

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September 22, 1955.

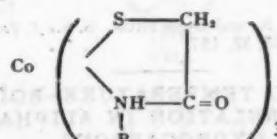
B. B. G. SARMA.

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COMPLEX OF TRIVALENT COBALT WITH *p*-(MERCAPTOACETAMIDO)-BENZOIC ACID

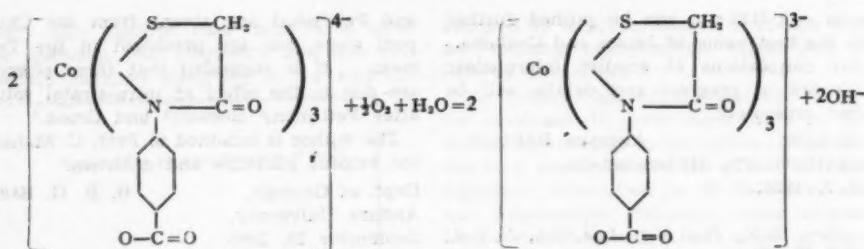
SOME derivatives of thioglycollanilide have been successfully used for the formation of complexes of cobalt.¹ The reagents can be represented by R-NH.CO.CH₂SH, where R is a phenyl or substituted phenyl group. Some of the complexes obtained are soluble whereas others are insoluble. The analysis of the insoluble compounds obtained with cobalt indicated that the complexes contain three ligands per atom of cobalt. It was therefore concluded that — NH.CO.CH₂SH group serves as a bidentate group. The solubility in water of the other complexes obtained with cobalt were due to the presence of carboxyl groups in the phenyl ring.

The insoluble cobalt complexes are therefore inner complexes. The primary conditions for the formation of inner complex is that the chelates should satisfy the co-ordination number and valency of the central atom. Hence cobalt was assumed to be trivalent and the ligand to be bidentate containing one negative and one neutral group and expressed by the structure



There is however no definite evidence that cobalt is trivalent and the chelates are bidentate. It was therefore thought worthwhile to investigate the above problem by magnetic measurement.

p-(Mercaptoacetamido) benzoic acid contains — NH.CO.CH₂SH group. The reagent is



soluble in alkali giving a colourless solution. An intense pink colour is produced when the alkali solution of the reagent is mixed with a solution containing divalent cobalt. This complex is expected to have a structure similar to the above.

If cobalt is trivalent and the co-ordination number is six, the compound would be diamagnetic. A known amount of cobalt sulphate was used with just excess of an alkaline solution of the reagent. The magnetic measurements were made with a magnetic balance. The compound was found to be para-magnetic at the beginning. The para-magnetism however decreased with time and after three hours the compound was found to be diamagnetic.

This indicates that the compound which is ultimately formed contains six co-ordinated trivalent cobalt. A divalent cobalt complex is probably formed at the beginning since cobalt hydroxide is not formed though an excess of alkali is present in the alkali solution of the reagent. The reaction can be represented by the structure given above.

Due to the oxidation of the cobaltous complex to cobaltic by oxygen of the air (which is the only available oxidising agent) the pH of the solution is expected to rise. This has been qualitatively observed.

Dept. of Chemistry, R. N. MISRA.
Ravenshaw College, S. PANI.
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CRITICAL TEMPERATURE-BOILING POINT RELATION IN ALIPHATIC HYDROCARBONS

The earliest and the simplest empirical formula connecting critical temperature, boiling point, and number of carbon atoms of normal hydrocarbons is due to Guldberg¹ and Guye²:

$$T_b/T_c = 2/3$$

But this relation is very approximate. Ferguson³ has correlated T_c , T_b and n by the formula:

$$T_c n^a = h T_b \quad (1)$$

$$\log T_b = \log T_c + g \log n - a \quad (1a)$$

where g , h and a are constants. But this formula is also of approximate nature. It can be further modified by introducing another constant. Thus the formula is:

$$c \log T_b = \log T_c + g \log n - a \quad (2)$$

Table I records the observed and calculated value of T_b by equation (2). Values of the constants are: $a = 1.106$; $c = 0.60922$ and $g = 0.07143$.

Data have been taken from *Landolt Bornstein Tables* and the *Handbook of Chemistry and Physics*.

For the first few members, an anomalous result is obtained which is due to the fact that most of the physical properties of the earlier members of the organic series do not tally with the regular behaviour of the higher members.

TABLE I

n	Paraffins	Temperature in deg. absolute		
		T_c (obs.)	T_b (obs.)	T_b (cal.)
1	Methane	190.7	111.5	84.92
2	Ethane	305.3	184.7	182.0
3	Propane	368.8	230.9	220.3
4	Butane	426.2	272.6	269.8
5	Pentane	470.4	309.1	300.0
6	Hexane	508	342	342.8
7	Heptane	540	371.5	372.4
8	Octane	569.4	397.6	399.0
9	Nonane	595.4	423.6	423.6
10	Decane	619.3	447	447.7
11	Undecane	642.6	470	469.5
12	Dodecane	663.8	489	489.8
13	Tridecane	683.2	507	508.8
14	Tetradecane	701	525.5	524.8
15	Pentadecane	717.6	543.5	543.3
16	Hexadecane	734.3	560.5	559.8
17	Heptadecane	749.3	576	575.4
18	Octadecane	763.2	590	589.5
19	Nonadecane	776	603	603.9

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The author acknowledges his indebtedness to Prof. S. Ghosh and Sri. S. S. Mitra for their kind help and suggestions in the investigation.

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Allahabad, March 31, 1955.

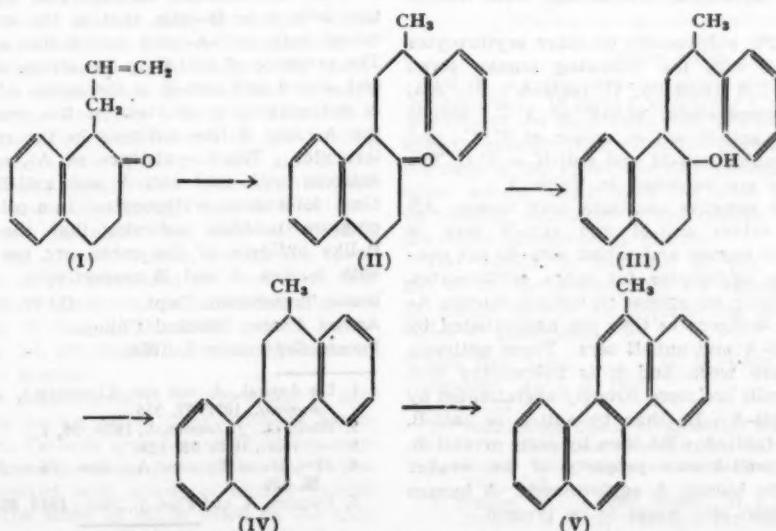
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mobile liquid, b.p. 140-45°/5 mm. (Calc. for $C_{15}H_{14}O$: C, 83.83; H, 7.58. Found: C, 84.12; H, 7.48.) The ketone (I) failed to furnish any solid 2:4-dinitro-phenylhydrazone or semicarbazone by the usual method and underwent oxidation on keeping. 1-allyl-2-tetralone (I) on being subjected to aluminium chloride catalysed condensation with thiophene-free benzene at 0-5° yielded 1-[β -methyl- β (phenyl)-ethyl]-2-tetralone (II) as a colourless viscous oil, b.p. 240-45°/6 mm. in 56% yield. (Calc. for $C_{19}H_{20}O$: C, 86.32; H, 7.63. Found: C, 86.10; H, 7.62.) The alkylated product (II) was reduced with aluminium isopropoxide in isopropyl alcohol to obtain 1-[β -methyl- β (phenyl)-ethyl]-2-tetralol (III) as a viscous tan mass in 72% yield, b.p. 225-30°/5 mm. (Calc. for $C_{19}H_{22}O$: C, 85.67; H, 8.33. Found: C, 86.17; H, 7.88.) Cyclisation of the carbinol (III) was effected with conc. sulphuric acid (sp. gr. 1.84) when 1:2:7:8:15:16-hexahydro-2-methyl chrysene (IV) was obtained in 58% yield, b.p. 220-25°/5 mm. (Calc. for $C_{19}H_{20}$: C, 91.88; H, 8.12. Found: C, 91.54; H, 8.00.) The above hexahydro-derivative was then aromatised over 30% palladium-on-charcoal catalyst to obtain a resinous product distilling at 215-20°/4 mm. in 55% yield. 242 mg. of the above furnished 385 mg. of a dark red picrate which crystallised from benzene-alcohol mixture in orange needles, m.p. 169-70° (lit.⁶ m.p. 170-70°). (Calc. for $C_{25}H_{17}O_7N_3$: N, 8.91; Found: N, 8.95.) 2-methyl chrysene (120 mg.) was regenerated from the above

A NEW SYNTHESIS OF 2-METHYL CHRYSENE

CATIONOID reactions between aromatic nuclei and γ , δ -unsaturated ketones and esters have been extensively employed in this laboratory to enable easy access to a wide variety of polycyclic aromatic hydrocarbon derivatives of naphthalene,¹ phenanthrene,² anthracene,³ 3:4-benzphenanthrene,⁴ and 1:2-benzanthracene⁵ series. The present communication reports a new synthesis of the chrysene system by a modification of the unsaturated ketone component in the alkylation reaction leading to an improved synthesis of 2-methyl chrysene.

β -Tetralone was alkylated with allyl iodide in boiling benzene in presence of dry sodamide prepared *in situ*, when 1-allyl-2-tetralone (I) was obtained in 61% yield as a colourless



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84.92
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524.8
543.3
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575.4
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603.9

picrate (385 mg.) and crystallised from light petroleum ether (b.p. 40-60°) in colourless leaflets, m.p. 160° (lit.⁶ m.p. 161-61.4°). (Calc. for C₁₀H₁₄: C, 94.18; H, 5.82. Found: C, 93.86; H, 5.75).

Microanalysis by Drs. Weiler and Strauss, Oxford.

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Hoshiarpur,
June 13, 1955.

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SOME SEROLOGICAL OBSERVATIONS ON THE BLOOD OF THE INDIAN COBRA (*NAIA TRIPUDIANS*)

SEROLOGICAL studies of snake blood have so far been confined to Europe and America.¹⁻⁵

As far as is known no similar studies of the blood of the Indian cobra, *Naia tripudians*, have been made. Blood from two Indian cobras having become available, it was decided to investigate their serological interactions with human blood.

Washed 2% suspensions of cobra erythrocytes were tested with the following human sera; B (anti-A), A (anti-B), O (anti-A+B), AB; at room temperature; anti-P at 4°C.; anti-D and anti-C, anti-E, anti-c, anti-e, at 37°C.; and also with rabbit anti-M and anti-N at 4°C. The interactions are recorded in Table I.

From the negative reactions with human AB sera, and rabbit anti-M and anti-N sera, it appears that human and rabbit sera do not contain species agglutinins for cobra erythrocytes. Cobra erythrocytes appear to contain human A- and B-like antigens as they are agglutinated by human anti-A and anti-B sera. These antigens, however, are weak and it is noteworthy that cobra red cells are more strongly agglutinated by O sera (anti-A+B) than by anti-A or anti-B, by O sera (anti-A+B) than by anti- or anti-B. This is a well-known property of the weaker forms of the human A agglutinogen. A human P-like antigen also seems to be present.

TABLE I
Reactions of various human and rabbit antisera with cobra erythrocytes.

Serum (undiluted)	Agglutination reactions with cobra erythrocytes	
	Cobra I	Cobra II
anti-A	++	W
anti-B	W	W
anti-(A+B)	+++	++
AB	-	-
anti-P	W	W
anti-D	-	-
anti-C	-	-
anti-E	-	-
anti-c	-	-
anti-e	-	-
anti-M	-	-
anti-N	-	-

++ = Fairly large agglutinates visible macroscopically; + = Weak agglutination seen macroscopically; W = Small agglutinates seen microscopically; - = No agglutination seen microscopically.

The sera of the cobras were inactivated and tested against a panel of human erythrocytes (2% washed cells suspended in isotonic saline) at 4°C., laboratory temperature, and 37°C. The serum of Cobra I when completely absorbed with O cells, failed to agglutinate A₁ and A₂ cells, but agglutinated B cells weakly in the cold. It appeared to contain a species agglutinin for human erythrocytes as well as anti-B agglutinin. The serum of Cobra II when similarly treated seemed to contain species agglutinins as well as agglutinins for human A and B cells. These could be separated by absorption with A or B cells, that is, the serum contained both anti-A- and anti-B-like antibodies. The presence of anti-B in the serum of Cobra I and anti-A and anti-B in the serum of Cobra II is not surprising in view of the weakness of the A- and B-like antigens in the cobra erythrocytes. The co-existence of A- and B-like antigens with cold anti-A and anti-B agglutinins (for human erythrocytes) in a cold-blooded creature possibly indicates that the A- and B-like antigens of the cobra are not identical with human A and B respectively.

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NAIL-HOLDING POWER OF A FEW MYSORE WOODS

THE Forest Research Laboratory, Bangalore, has a Universal "Timber" Testing Machine made by Mohr and Federhaff, Mannheim, Germany, for testing small clear specimens of timber. The makers describe the various tests to which the machine can be adapted; nail-holding capacity is, however, not amongst the adaptations suggested. The present paper describes an adaptation of the machine for this purpose, and the experimental results obtained with some Mysore woods.

The machine has two U-shaped grip heads, the one inverted attached to the movable head, and the other fixed by the bottom movable rod. Two rectangular steel plates $3\frac{1}{2}'' \times 1\frac{1}{8}''$ with thickness of $\frac{1}{8}''$ or $\frac{1}{4}''$ with suitably bevelled edges and a hole in the middle that would allow the nail to pass but not its head are placed over the wood specimen ($1\frac{1}{4}'' \times 1\frac{1}{4}'' \times 3''$) to be tested; a 2" nail of 12 S.W.G. was driven through the holes of the steel plates into the wood either 1" or $1\frac{1}{4}''$ deep, exclusive of the point, as required in the experiment. After driving the nail, the steel plates separated from one another are placed in the two grip heads. The machine head was then run at a uniform speed of 10 mm. per minute till the maximum load required for withdrawal of the nail was recorded.

All the thirty-three species of woods tested were air-seasoned. Owing to paucity of properly air-seasoned wood the number of specimens tested was limited to 6-24.

It was found that in general denser woods offer greater resistance to direct withdrawal of nails than less dense woods. Among the variations in this general rule mention may be made of *Elaeocarpus serratus*, which is about 50% stronger than *Grevillea robusta* in nail-holding power though both of them have almost the same specific gravity and moisture content. *Holigarna arnottiana* though lighter than *Grevillea robusta* has almost the same nail-holding power as the former. Again, though the specific gravity of *H. arnottiana* is lower than that of *Ailanthus malabarica*, its nail-holding power is superior to that of the latter. Such variations may be attributed to other characteristics of the species.¹

In these experiments it is interesting to note that woods having oil in them, such as *Santalum album*, *Tectona grandis* and *Machilus macrantha*² have low values for nail-holding power, when compared with woods of similar specific gravity. The effect of oil in wood on the nail-holding power is worth further investigation.

The denser woods are found to have a tendency to develop cracks and split while nailing. This tendency is aggravated in "exceedingly" heavy woods like *Soymida febrifuga* and *Hardwickia binata*. It is also observed that light woods such as *Ailanthus malabarica*, *Cedrela toona*, *Elaeocarpus tuberculatus*, *Holigarna arnottiana*, *Hymenodictyon excelsum*, *Kydia calycina* and *Salmania malabarica* have comparatively low nail-holding power; they have less tendency to crack and split, and hence are capable of taking greater number of nails than denser woods. Nail-holding power of woods has shown improvement when the nail is driven to a greater depth into the wood. It is also observed that resistance to withdrawal is greater when nails are driven into the side grain than when driven in the end grain of wood.²

Fig. 1 is a curve obtained by plotting the nail-holding power of different species of woods

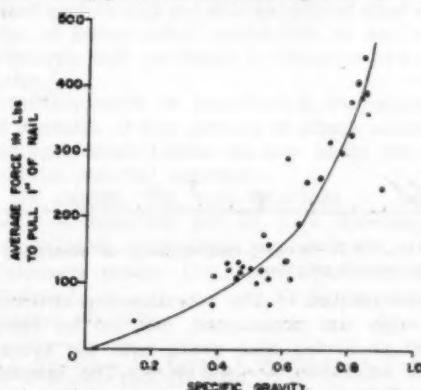


FIG. 1. Relation between specific gravity and nail-holding power. 12 gauge 2" nails driven 1" deep into the side grain of well air-seasoned wood and pulled at once, tested, against their specific gravities. With the help of the curve the nail-holding power of other woods, which have not been tested, can be roughly estimated if the specific gravity of the wood concerned is known.¹

The author is thankful to his colleagues, Dr. M. N. Ramaswamy for his suggestions, and D. Range Gowda for determining specific gravities of specimens.

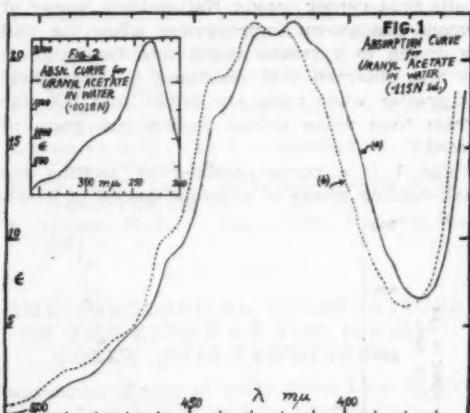
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INTENSITY MEASUREMENTS IN ABSORPTION AND FLUORESCENCE OF URANYL ACETATE SOLUTION

ABSOLUTE intensity measurements in absorption spectra of uranyl acetate solution in water under various dilutions have been taken in the range 5000-2000 Å. Intensity distribution in the fluorescence spectrum has also been investigated.

In strong solutions the curve upto 3800 Å (Fig. 1, a) resembles the curve for uranyl



FIGS. 1 & 2. Intensity measurements of absorption of uranyl acetate solution.

nitrate solution.¹ The vibration-like structure, although less pronounced, can yet be recognised as having nine peaks with the average band separation $\Delta\nu \sim 670 \text{ cm}^{-1}$. The inequalities of $\Delta\nu$ are markedly larger, and the structure, which in the nitrate extends upto 3480 Å, is entirely missing here below 3750 Å, from where a continuum sets in. In the banded region the absorption maximum in strongest solutions is at 4170 Å, but the 4270 Å band, which is only a little less intense, gains definitely over the 4170 Å band with increasing dilution. The absorption curve in the ultraviolet (Fig. 2), observed with very dilute solutions, shows a continuum with three regions of peak absorption at 3400 Å, 2900 Å and 2300 Å. The last one probably wholly belongs to the acetate ion. The values of molar extinction coefficient at 4270 Å, 3400 Å, 2900 Å (and 2300 Å) are respectively 59, 270, 1020 (and 2720) with 0.0018 N solution. At the maximum absorption band (4270 Å) the acetate solution absorbs 5 times compared to the maximum absorption band in the nitrate solution. The ultraviolet

continua obviously pertain to different electronic transitions, which have higher transition probability than that associated with fluorescence emission. It is found that for concentrations varying from 0.115 to 0.0018 N, under which absorption in the visible region has been observed, Beer's law is not obeyed, although the nature of the curve remains unaltered, the deviation being largest for the 4270 Å band.

Another sample of uranyl acetate, a Swedish product not of the A.R. grade, gave an absorption curve (Fig. 1, b) similar to the one described above, except that there was shift of the entire curve towards the shorter λ side by about 30 Å. In the fluorescence of solutions the continuum² is similar for the two samples, but while the peak for the A.R. grade falls at 5200 Å, that for the other is shifted 30 Å to the longer λ side. It is interesting, however, that in the solid state the fluorescence spectra of the two samples show a very marked difference. The Swedish product gives a spectrum shifted to the ultraviolet by about 110 Å, and several other differences both with regard to intensity distribution in the bands and in the nature of spectra have also been observed.

Details will be published elsewhere.

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ASSAY OF ROOT EXUDATES

RECENT studies on root exudates¹ have opened up a new field of investigation in understanding rhizosphere activity.² In this field of enquiry two promising techniques have been evolved and they are reported hereunder.

The first technique consisted of growing plants (*Eleusine coracana* Gaertn., *Oryza sativa* Linn., *Phaseolus mungo* Linn., *P. radiatus* Linn., and *Cicer arietinum* Linn., were used by us for our preliminary observations) from seeds previously surface sterilized and germinated on sterile agar and planted in sterile 1/10 N Richard's solution without sucrose (using Analar chemicals) in Roux tubes. The seedlings were allowed to grow for a fortnight after which the liquid substratum was withdrawn and autoclaved in culture flasks with addition of 0.5% sucrose. A strain of *Piricularia oryzae* Br. et Cav., heterotrophic to thiamine and biotin^{3,4} used in previous investiga-

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tions in this laboratory was then seeded in this substratum. Aliquots of 1/10 N Richard's solution in which no plants were grown, with the addition of 0.5% sucrose, served as control. The fungus was observed to grow well in media in which plants had grown, but not in the controls. This is suggestive of the presence of root exudates having thiamine-biotin replacement value. The value of this technique is

dates are extracted by subjecting the tube B and the metabolite solution to the perfusion technique of Lees and Quastel,⁵ with certain effective modifications on the design developed by Jefferys⁶ and the metabolites subsequently evaluated by using modern bioassay and chromatography techniques. In a recent paper a somewhat similar technique has been described⁷ but we believe that one of the limitations of that technique is the abnormal condition for plant growth under restricted aerobic and light intensity conditions, whereas in the present technique the plants can be maintained singly under conditions favourable for normal photosynthetic and respiratory activities. This compact unit has the advantage of seldom requiring adjustment, of having no rubber connections and does not seem to be subject to air-borne microbial contamination. Further sampling of the metabolite from container A at intervals is made possible without disturbing plant growth and the unit permits of easy addition of heavy metal metabolites or any other chemicals that are likely to influence root exudates.

Further work on quantitative determinations of exudates of root systems of plants under the influence of antibiotics are now under way and will be reported elsewhere.

We express our deep gratitude to Professor T. S. Sadasivan and Dr. C. V. Subramanian for valuable suggestions and guidance.

University Botany Lab., K. BHUVANESWARI.
Madras-5, C. B. SULOCHANA.

October 14, 1955.

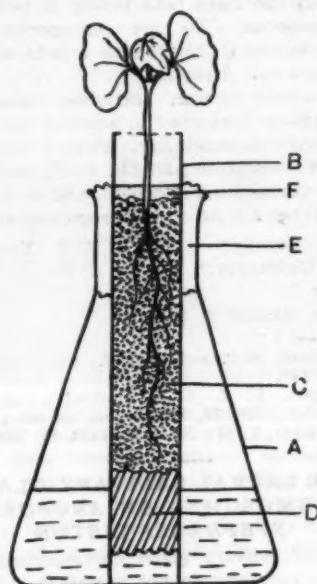


FIG. 1.

mainly its simplicity and adaptability to qualitative and quantitative bioassay of vitamins from root exudate under aseptic conditions.

The second technique developed here is again a simple design for growing seedlings under controlled conditions in natural soils with the advantage of obtaining root exudates produced *in situ* in soil without injuring the root system (Fig. 1). It consists of a Pyrex container A with distilled water, Pyrex tube B open at both ends, containing a layer of soil C plugged with glass wool at D and kept in position by an annular ring of cotton plug E providing the necessary aeration to the liquid substratum. A layer of acid-washed sand F is placed above the column of soil and this has been found to minimise to a considerable extent contamination from air-borne micro-organisms. By the combined capillary action of the soil and glass wool the moisture level of the soil is automatically maintained at an optimum level throughout the course of the experiment. Root exu-

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CYTOTAXONOMY OF INDIAN SPECIES OF CITRULLUS

THE genus *Citrullus* is represented in India by *C. vulgaris* Schrad. (watermelon) and *C. colocynthis* Schrad. (Colocynth). Besides these two species there is the common vegetable 'Tinda' which is taxonomically treated as a variety of watermelon, *C. vulgaris* Schrad. var. *fistulosus* Stocks. This variety is indigenous to India.

Crosses were made in all directions between these taxa, but only those between *C. vulgaris* and *C. colocynthis* succeeded. The two species resemble in the vegetative and floral characters but differ in the fruit. In *C. vulgaris* the fruit is big with a thick fleshy rind and contains pink, loose, watery and sweet pulp, while in *C. colocynthis* the fruit is comparatively very small with thin cartilaginous rind and contains white, compact, spongy and bitter pulp. The bitterness is due to the presence of Colocynthin, to which it also owes its medicinal properties.

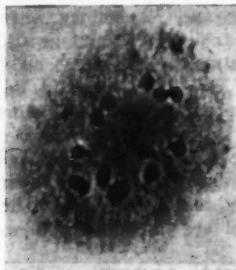


FIG. 1. Twelve bivalents in a pollen mother cell of *Citrullus vulgaris* var. *fistulosus*, $\times 1,075$.

All the F_1 plants showed marked heterosis and had bitter fruits. The two reciprocal hybrids showed strong matrocliny which is perhaps due to the cytoplasmic genes. The parents and the hybrids possess $2n = 22$ and $n = 11$ which is in conformity with the observations of Whitaker.³ The chromosomes are very small; hybrids had nearly regular meiosis except for a few univalents at metaphase I and bridges at anaphase I. This resulted in 30–40% pollen and about 35% seed fertility. F_2 was not analysed, but three plants out of 50 showed diplontic sterility.

Incidentally it may be mentioned that there is a possibility of raising better strains of colocynth which ordinarily possesses about 15 fruits per vine each weighing 4–6 oz. The writer noted some plants in the hybrid progeny which combined the useful characters of the two parents, namely, big size and weight (approximately 6 lb.) of watermelon and bitter and spongy pulp of colocynth. On the average these plants bore 6 such fruits.

The crosses involving var. *fistulosus* whether as male or as female parent were always unsuccessful in spite of the repeated attempts. A morphological comparison of this variety with either species indicated many differences involving all the parts of the plant including

pollen grains and chromosome number. This variety has $2n = 24$ and consequently 12 bivalents in pollen mother cells (Fig. 1). The size of the chromosomes is much bigger than watermelon and colocynth. Naithani and Das¹ have reported $n = 11$ for this variety which the author was unable to confirm. The present observations agree with those of Pangalo.²

The above evidence indicates that biosystematically the three taxa belong to two different cenospieces. To one cenospiece belong *C. vulgaris* and *C. colocynthis* and to the other *C. vulgaris* var. *fistulosus*.

A detailed account including taxonomical aspect will be presented in another paper.

The writer is indebted to Prof. P. N. Mehra, Dr. T. W. Whitaker and Dr. C. F. Andrus for their encouragement and help, and to Mr. R. S. Pathania for taking the microphotograph.

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THE LARVAL SALIVARY GLAND CHROMOSOMES OF ANOPHELES STEPHENSI LISTON

The larval salivary gland chromosomes of the mosquito normally do not present a sufficiently clear and well-defined structure suitable for detailed study. Sutton¹ however found that the salivary chromosomes of *Culex pipiens* showed a structure which would enable maps to be drawn similar to those of *Drosophila*; but in *Aedes aegypti* the presence of certain "weak-spots" rendered it difficult to follow the banding pattern throughout the entire length of the chromosomes. Frizzi² discovered that by rearing the larvae in special culture media the nature of the salivary preparations could be greatly improved. This enabled him to successfully map the salivary chromosomes of *Anopheles maculipennis* variety *atroparvus*.

A study of the salivary chromosomes of *Anopheles stephensi* type form was undertaken and the results obtained are quite encouraging. A laboratory colony of the type form was established in order to provide a continuous and plentiful supply of genetically homogeneous material for the purposes of this investigation. Larvae for dissection were isolated in small numbers in water corrected for pH and fed

well on yeast. During the final instars suitable quantities of infusorian culture were also added to the rearing medium. The salivary chromosomes in preparations obtained from these larvae were usually large and showed well-defined banded pattern along their major lengths.

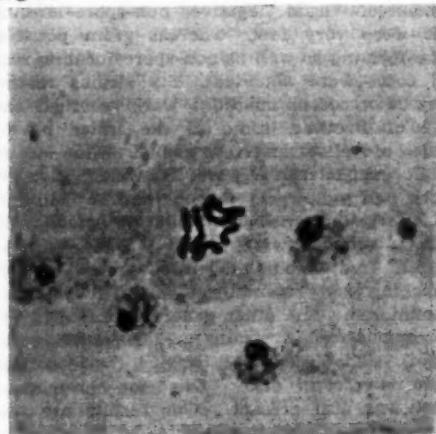


FIG. 1. Metaphase in a brain cell of the larva. From acetic-orcein squash preparation. Approx., $\times 1,300$.

The aceto-carmine squash technique of Painter³ was employed with certain modifications. The glands dissected out in normal saline were first fixed in a modified Carnoy's fluid for a short period as recommended by Nolte,⁴ which

lessened the fragmentation of the chromosomes and gave better differential staining. Orcein was found to give a deeper stain to the chromosomes as compared with carmine. Preparations were made permanent according to the method outlined by McClintock.⁵ The mitotic chromosomes were studied from simple acetic-orcein squashes of the larval brain.

The salivary gland consists of two lobes, of which the proximal is rounded and the distal, elongated. The proximal lobe consists of about 20 relatively large cells and the distal lobe of about 60 smaller cells. The cells of the proximal lobe possess giant nuclei and a few of these cells disposed about the middle of the lobe are best suited for the detailed study of the salivary chromosomes.

The mitotic metaphase sets of *Anopheles stephensi* type consist of two pairs of V-shaped and a pair of rod-shaped chromosomes (Fig. 1). The rod-chromosomes appear to be connected at one of their ends with heterochromatic dots and constitute the sex-chromosomes. In the salivary gland nuclei the homologues are synapsed together along their entire lengths. Their centromeres are united together to constitute a common chromocentre, from which the individual chromosome arms radiate out. Each V-shaped pair thus shows two arms corresponding to the two arms of the V, whereas the rod-shaped pair shows only a single arm. *Anopheles stephensi* type exhibit five salivary chromosome elements connected by a common

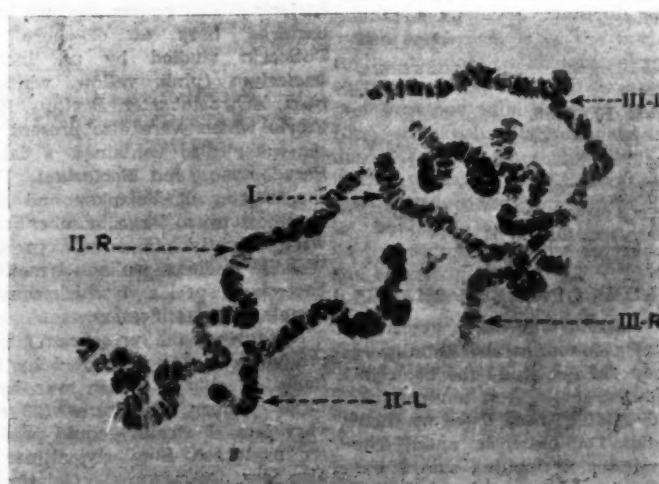


FIG. 2. The larval salivary gland chromosomes. From acetic-orcein squash preparation. Approx., $\times 500$. The roman numerals indicate the chromosome arms mentioned in the text.

chromocentre. The chromocentre however appears to be not a compact structure and becomes easily ruptured on pressure with the result that the five chromosome elements tend to lie separate in well-squashed preparations (Fig. 2).

The sex-chromosome is the shortest element and is designated Chromosome I. The first pair of V-chromosomes constitute Chromosome II and possess two arms, called II-R and II-L respectively. The second pair of V-chromosomes constitute Chromosome III, also showing two arms, respectively known as III-R and III-L.

The individual chromosome arms are identified in a tangle on the basis of certain "landmarks" besides their free ends which are usually characteristic. Chromosome I in addition to being easily recognised by its short length, possesses a distinct "swelling" about its middle. Each of the remaining four chromosome elements is marked by at least two well-defined zones which help to distinguish them easily. The free ends of these chromosome arms are also characteristic excepting that of Chromosome III-R. The serial arrangement of the bands along the length of the individual chromosome arms together with the infra-specific variations in the salivary chromosomes are being worked out.

I wish to thank Dr. K. K. Nayar for guidance, Dr. A. P. Mathew for facilities, and Mr. B. N. Mohan of the Malaria Institute of India, Coonoor, for kindly supplying me with live eggs of *Anopheles stephensi* type form which enabled me to start a colony in this Laboratory.

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N. RISHIKESH.

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BACTERIAL FLORA OF FRESH SHARK*

In a recent note,¹ Velankar and Sastri described the types of bacteria found in sharks allowed to spoil. Since they did not study the bacterial flora of freshly caught shark, it is not possible to say whether the spoilage flora listed by them is the intrinsic flora or extrinsic ones. The occurrence of the latter in spoiling sharks has been noted by Wood.² In this note we are

presenting the results of investigation on shark *Carcharhinus* spp. The huge shark was caught off Tuticorin by R. C. Hooks and was alive. The flora of the skin was plated out on board under aseptic conditions, before the shark was lowered on the deck.

The majority of colonies on the plates were pigmented. Gram negative, non-spore-forming rods were very few, whereas gram positive, spore-forming as well as non-spore-forming rods and cocci were abundant. Six strains resembling *Micrococcus cundidus* were recorded and nine of *Bacillus*, some of the latter having shades of yellow and rose colour. Nine strains of *Corynebacterium* were identified, five of which had yellow chromogens and two pink to red. *Corynebacterium helvolum*, *C. globiforme* and *C. simplex* were noted. One strain of pinkish red, non-acid fast gram positive branching rod resembling *Nocardia* was also encountered. The other genera represented are *Achromobacter* (3 strains), *Flavobacterium* (1 strain) and *Vibrio* (1 strain) besides four other micrococci also. One non-chromogenic yeast was also present. Our results are thus in agreement with the findings of Wood² with regard to the types of bacteria present on shark. We did not however notice any *Pseudomonas* or *Proteus*. It is of further interest to note that Japanese workers³ also identified *Corynebacterium*, *Micrococcus*, *Flavobacterium* and *Achromobacter* on sharks, while Velankar and Sastri did not find any *Corynebacterium* on shark. Wood² is of the opinion that *Corynebacterium* also causes spoilage of sharks. The bacterial flora of off-shore sea-water off Tuticorin studied by us, included *Corynebacterium* (pink, yellow, white), *Flavobacterium*, *Achromobacter*, *Bacillus*, *Micrococcus* and *Vibrio* which were also present in sharks. The sea-water also contained a large number of *Pseudomonas* and *Bacterium*. While none of the isolates of Velankar and Sastri produced chromogens, a large number of our cultures were brightly pigmented. In agreement with Wood's² findings, we noted motility in *Corynebacterium*, species of which could be fitted into Topping's⁴ classification.

As against the presence of indole and H₂S producers in teleosts noted by us,⁵ none were found in shark. Starch was hydrolysed by a large number of cultures (23 out of 34) but very few (8 strains) could produce faint acidity in glucose. Similarly, nitrate reducers, were also few (10 cultures). Gelatin liquefiers were abundant (25 strains) while milk-peptizing cultures were not many (10 numbers). Two cultures produced urease in Christensen's

* Published with the permission of the Director of Industries and Commerce Madras

medium. It is possible that more of them would prove urease positive in media such as Gibson's, as was noted by us in the case of urea-splitting bacteria from 'Chanks' (unpublished, 1954). Enrichment cultures showed production of ammonia from urea, when dilutions from the surface swab were inoculated, into them. The enrichment of gram-positive types such as *Corynebacterium*, *Bacillus* and *Micrococcus* in shark accord well with the findings of Wood.² In view of the findings of Castell³ that trimethylamine oxide (which is present in large quantities in elasmobranchs⁷) has inhibiting action on gram-positive organisms, it is surprising that there is a rich and varied gram-positive flora on fresh shark as noted by us here and by Wood² in Australia.

Further work is in progress. Our thanks are due to Sri. N. V. Choodamani, Assistant Director of Fisheries, Tuticorin, for providing the necessary facilities.

Fisheries Technological Station, Kozhikode,
September 26, 1955.

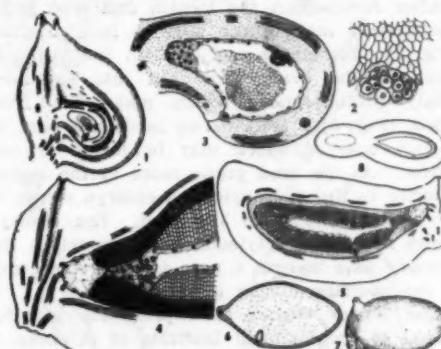
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ENDOSPERM AND SEED DEVELOPMENT IN *CHRYDALOCARPUS LUTESCENS* H. WENDEL.

Chrysalidocarpus lutescens H. Wendel. is a common ornamental palm belonging to the tribe Arecinae. The fertilisable ovary in this species is laterally compressed and lop-sided and shows a single uniovulate loculus; it is surmounted by three sessile stigmas. The ovule is transverse, hemianatropous, crassinucellate and bitegmic. The micropyle is straight and formed by both the integuments; it is situated a little inner to the anterior end of the ovule and faces the base of the loculus. Its cylindrical massive funicle shows a core of parenchyma surrounded by a ring of 15-20 vascular bundles which traverse in the outer integument nearly to the micropyle. The embryo sac which develops according to the Normal-type

crushes out all the nucellar cells except the postament which stands opposite to the micropyle. The secondary endosperm nucleus is seen close to the egg apparatus and the three multi-nucleate persistent haustorial antipodal are located in the postament (Figs. 1, 2). The



FIGS. 1-8. *Chrysalidocarpus lutescens*. Fig. 1. L.S. fertilisable ovary, $\times 1\cdot5$. Fig. 2. Postament from fertilisable ovule with antipodal, $\times 23$. Fig. 3. Early stage in the development of endosperm haustorium, $\times 13$. Fig. 4. Part of the fruit showing endosperm haustorium at a later stage, $\times 1\cdot2$. Fig. 5. L.S. developing fruit, $\times 0\cdot4$. Fig. 6. L.S. mature seed, $\times 0\cdot2$. Fig. 7. Entire fruit, $\times 0\cdot4$. Fig. 8. L.S. 2-lobed fruit, $\times 0\cdot2$. embryo sac contains dense cytoplasm rich in starch.

Fertilisation is porogamous. The course of pollen tubes is facilitated by the glandular cells that line the top of the loculus. Egg fertilisation is completed after a few endosperm nuclei are formed.

The endosperm is of the nuclear type. Early in development, a chalazal aggregate of endosperm nuclei arises (Fig. 3) and in due course this develops into a massive nuclear haustorium. It expands aggressively crushing out all the overlying parenchymatous and tannin-bearing cells of chalaza and funicle and comes into direct contact with the placental vascular bundles (Fig. 4). The haustorium shows deep staining dense protoplasm rich in starch, and several polyploid nuclei formed by nuclear fusions. Since its cytoplasm runs continuous with the nuclear endosperm surrounding the central vacuole in the main body of the seed, it facilitates rapid transport of food which it receives directly from the placental vascular bundles to the developing embryo (Fig. 5). The endosperm of the haustorium does not become cellular; it appears as a dark mass in the mature seed (Fig. 6).

The endosperm in the main body of the seed becomes cellular by simultaneous cell plate

formation. In the fully developed seed, the endosperm shows two zones: a peripheral one consisting of regular rows of radially elongated cells and a central one of cells irregular in shape and distribution. The cells show thick-walled walls which store hemicellulose.

After fertilisation the loculus and seed grow transversely making the stigmas look 'basilar' (Fig. 7). Sometimes one or both the vestigial loculi of the ovary grow out into succulent empty protuberances which make the fruit lobed (Fig. 8). Rarely two seeds are seen in a fruit both of which may be fertile or one sterile. As the seed grows more in the region anterior to the micropyle, the embryo comes to lie about midway in the seed. The embryo shows a massive cotyledon which envelops the primary axis leaving a pore for the emergence of the plumule during germination.

The writer wishes to express his grateful thanks to the National Institute of Sciences of India for the award of a senior Fellowship during the tenure of which this study was made.

Dept. of Botany,
Andhra University,
Waltair, July 25, 1955.

C. VENKATA RAO.

TWO NEW SPECIES OF THRIPS (*OXYRRHINOTHrips*)

THREE species of *Thrips* (*Oxyrrhinothrips*) are reported from India; these are *T. (O.) Oryzae*, *T. (O.) Beharensis* and *T. (O.) Scolopex*. Two new species of the sub-genus have been collected and are described herein. Their complete description will be published subsequently.

Thrips (Oxyrrhinothrips) Schusteriana sp. nov.

Holotype Female (Measurement in microns).—Total length 951. Head length 128, width 126; distance between anterior and posterior ocelli 17, between posteriors 24, length of post-ocellar bristle 24, and longest post-ocular 23. Mouth cone 107. Maxillary palpi (from paratype) basal segment 10, middle 10, apical 13. Prothorax: length 113, width 129, length of posterior angular bristles outer 40, inner 51. Length of tibia: fore 100, hind 144. Length of antenna 214; segments (width in brackets) III 38 (17), IV 33 (16) and V 36 (15).

General Description.—Yellow, eyes black, ocelli with crimson pigmentation. Antennal segment I to IV and basal half of V and VI are lighter, apical half of V and VII and VIII entire brownish. Wings uniformly coloured, lighter than body with negligible brown tinge. A row of six bristles running parallel to the hind margin of the compound eyes. One pair of prominent bristles to the inner side of the

fore margin of the eyes. Mouth cone just surpassing the posterior margin of posternum. Antennal segments I and II normal, III and IV cylindrical with forked trichomes. Legs uniformly yellow with tarsal tip dark. Wings with 23 bristles to costa, 4+4+1+1+1+1=13 to forevein, and 10 to hindvein.

Host: Sugarcane (leaf-sheath). Collected by Shri N. G. Patel at Baramati (Poona District) on 6-7-1952.

Thrips (Oxyrrhinothrips) bambusae sp. nov.

Holotype Female (Measurements in microns).—Total length 1248. Head length 87, width 122; distance between anterior and posterior ocelli 9, between posteriors 20, length of post-ocellar 16, and length of longest post-ocular bristle 35. Maxillary palpi; basal 19, middle 12 and apical 16. Length of prothorax 125, width 109; length of posterior angular bristle outer 51, inner 51; length of tibia: fore 110, hind 153. Length of the antennal segments (width in brackets) III 45 (14), IV 42 (12) and V 34 (17). Total length of the antenna 243.

General Description.—Brown, head and 4-6 abdominal segments decidedly darker than the remaining parts; prothorax lighter than pterothorax, all legs light; wings transparent but uniformly light brown except near the base which is lighter. Tip of the mouth cone darkest spot in the insect. Ocelli prominent without pigmentation. Antennal segments I to III, basal half of IV and slight basal of V are lighter, remaining brown, shape normal III and IV being little slender with forked trichomes and VI with long simple sense cone. Wings normal, both fore and hind fringe to the forewing starts before the middle of the border; Costa with 24, forevein, 4+3+1+1+1=10 and hindvein with 13 setae.

Host: Bamboo. Collected at Poona by Shri N. G. Patel.

We are indebted to Dr. G. D. Morrisson, N. Scotland College of Agriculture, Aberdeen (U.K.), for having examined the slides, and to Dr. H. Santapau, Botanical Survey of India, Calcutta, for advice in coining the correct names.

Entomology Laboratory, G. A. PATEL.
College of Agriculture, N. G. PATEL.
Poona, July 17, 1955.

A CONTRIBUTION TO THE MORPHOLOGY AND EMBRYOLOGY OF *FICUS RELIGIOSA* LINN.

EMBRYOLOGICAL work on the family Moraceæ, especially the genus *Ficus*, is very meagre. Cunningham³ studied fertilization in *F. rox-*

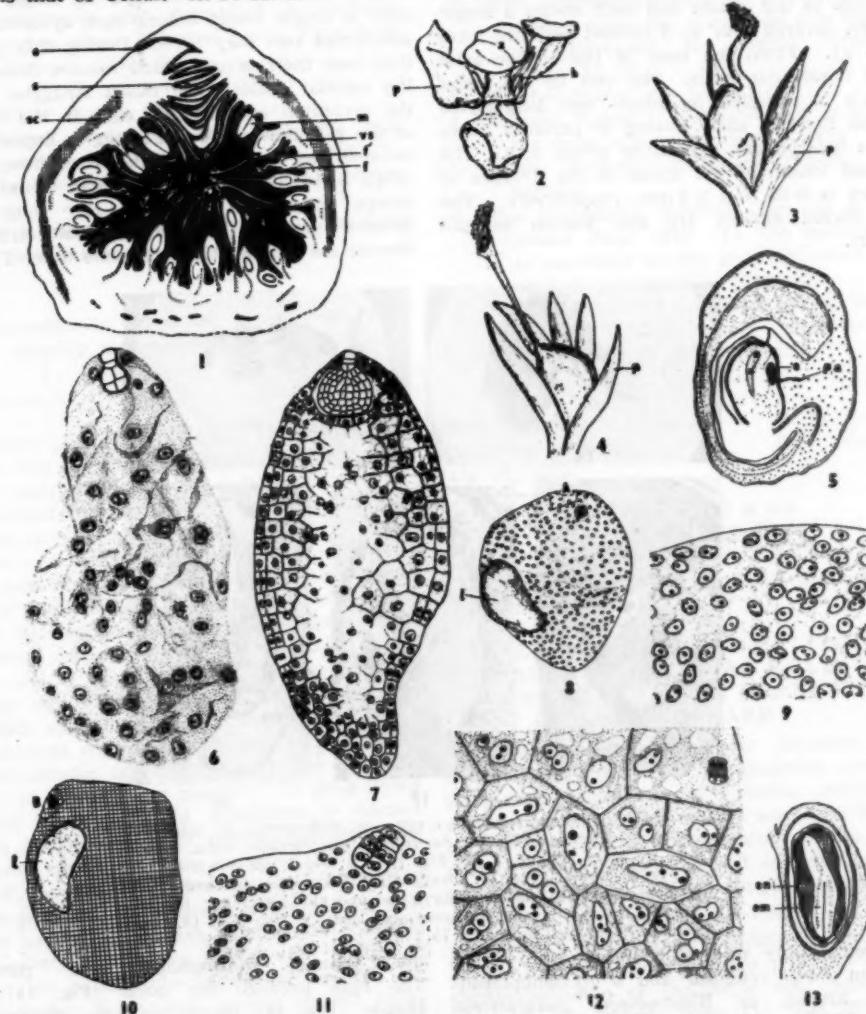
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Letters to the Editor

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burghii and Treub⁴ reported the production of parthenogenetic embryos in *F. hirta*. The chief work is that of Condit¹ on *F. carica*.

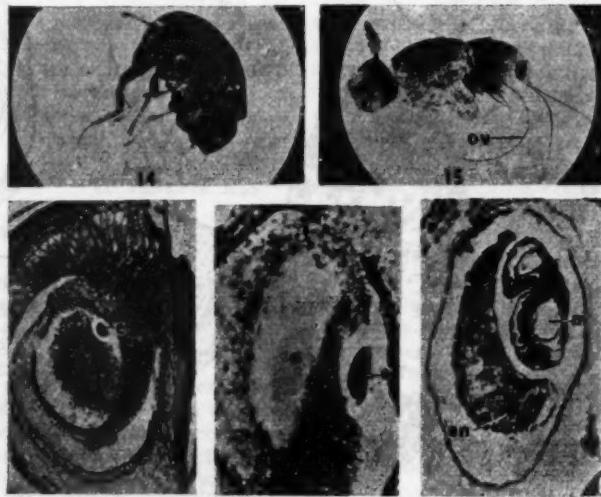
In *F. religiosa*, the cymose inflorescences coalesce to form a fleshy, hollow axis bearing unisexual flowers on the inner side. This syco-



FIGS. 1-13. *a*, anther; *c*, egg; *cm*, embryo; *en*, endosperm; *f*, short-styled flower; *f'*, long-styled flower; *h*, hairs; *l*, larva; *m*, male flower; *o*, ostiole; *p*, perianth; *pa*, path of ovipositor; *s*, scales; *sc*, sclereid zone; *ss*, vascular supply. Figs. 6 and 8-12 from dissected whole mounts rest from microtome sections. Fig. 1. L.s. syconium (diagrammatic), $\times 3$. Fig. 2. Male flower, $\times 7$. Figs. 3, 4. Short- and long-styled female flowers, $\times 7$. Fig. 5. L.s. ovary (gall flower) showing the egg of *Blastophaga* lodged between the nucellus and the inner integument, $\times 30$. Fig. 6. Free nuclear endosperm and 6-celled proembryo from long-styled flower, $\times 267$. Fig. 7. L.s. endosperm and embryo, long styled flower; centripetal wall formation has occurred, $\times 267$. Fig. 8. Free nuclear endosperm with proembryo (slightly displaced) and larva (gall flower) (diagrammatic), $\times 75$. Fig. 9. Enlargement of portion marked A in Fig. 8, $\times 267$. Fig. 10. Advanced stage of endosperm and larva (gall flower) (diagrammatic), $\times 75$. Fig. 11. Portion B of Fig. 10 enlarged to show multinucleate condition of endosperm cells, $\times 267$. Fig. 12. Endosperm tissue (gall flower) with polyploid nuclei, $\times 267$. Fig. 13. L.s. seed, long-styled flower, $\times 30$.

nium has an apical ostiole which is more or less closed by overlapping scales (Fig. 1). Twelve to eighteen male flowers are situated adjacent to the ostiole and each shows a single stamen covered over by 3 hooded perianth lobes (Fig. 2). From the base of the anther arise some unicellular hairs. The rest of the inner surface is occupied by short- and long-styled female flowers, each having 5 perianth lobes and a bicarpellary gynoecium (Figs. 3, 4). The average length of the styles in the 2 types of flowers is 0.65 and 2.3 mm. respectively. The short-styled flowers are also known as gall flowers.

enter younger syconia which develop side by side with the ripe ones and their ovules are usually at the mature embryo sac stage. Generally a single insect enters each syconium but sometimes two may enter. During this process they lose their wings which remain sticking to the ostiolar scales. The insect struggles inside the syconium and lays its eggs in the ovaries of the gall flowers. A single egg is deposited in between the nucellus and the inner integument (Figs. 5, 16, 17). Some of the gall flowers may escape oviposition while a few long-styled flowers may be oviposited. Both types of flowers are pollinated at the same time. Finally,



FIGS. 14-18. Photomicrographs. *e*, egg; *en*, endosperm; *m*, maggot; *ov*, ovipositor; Fig. 14. *Blastophaga quadraticeps*, male, $\times 22$. Fig. 15. Same, female, $\times 20$. Fig. 16. L.s., ovary, gall flower (same as Fig. 5), $\times 65$. Fig. 17. Ovule of Fig. 16, from a different serial section, showing healthy embryo sac and the insect egg lodged between the nucellus and the inner integument, $\times 202$. Fig. 18. L.s., immature seed, gall flower, $\times 73$.

A remarkably interesting relationship exists between *Ficus religiosa* and a hymenopterous insect known as *Blastophaga quadraticeps* (Figs. 14, 15). When a mature syconium is ready to fall off from the tree, the wingless males burrow a hole through the ovary walls and escape into the space between the flowers. They fertilize the females (Flander, 1945; see Condit²) and perish in the syconium. Now the female insects also come out of the ovaries and at this time the scales around the ostiole loosen and allow them an easy exit. While escaping, they incidentally get dusted with pollen. Soon after emerging from a syconium, they

the female *Blastophaga* also perishes. The eggs produce the male (Fig. 14) and female (Fig. 15) insects and the life-cycle is repeated. Condit¹ has also given an account of pollination in *F. carica*. In this species the pollinating agent is *B. psenes*.

In both the types of flowers the development of the female gametophyte conforms to the Polygonum type but the following comparisons are noteworthy.

Longo (1909, see Condit¹) observed amitotic divisions in the endosperm of the gall flowers of *F. carica* but Condit¹ does not refer to any such behaviour in this species; nor are we able

Long-styled flowers

Short-styled or gall flowers

1. The endosperm is Nuclear (Fig. 6).
2. Centripetal wall formation is initiated when about 170 free nuclei have been formed (Fig. 7).
3. Mitotic figures are regular.
4. Nuclear fusion is rare and the cells mostly remain uninucleate (Fig. 7).
5. The nuclei are spherical or oval in shape.
6. A normal embryo is formed and the seed is albuminous (Fig. 13).
7. Occasionally, however, *Blastophaga* may develop in approximately 8% flowers.

1. The endosperm is Nuclear (Figs. 8, 9).
2. Wall formation occurs by cleavage furrowing when the number of free nuclei has increased to several hundred (Figs. 10, 11).
3. Mitotic figures are irregular.
4. Nuclear fusion is common and most of the cells are multinucleate (Fig. 12).
5. Large irregular polyploid masses are formed.
6. The proembryo develops only up to the octant stage (Fig. 11), the endosperm is consumed by the growing insect and seed formation fails (Fig. 18).
7. The achenes contain *Blastophaga*, but a normal embryo may develop in approximately 40% flowers.

to confirm it in *F. religiosa*. Condit¹ further reports that in the gall flowers of *F. carica* he noticed only an occasional enlargement of the egg without any subsequent development into an embryo. To quote his own words: "Some egg cells show a slight increase in size, but none show any indication of mitosis of the egg nucleus". He goes on to say that "oviposition by the blastophaga so injures the stylar canal that there cannot be a growth of pollen tubes to the ovule. However, such flowers regularly develop endosperm, a tissue which furnishes the main subsistence of the blastophaga larva. The obvious inference that this endosperm is parthenogenetic is confirmed by the determination of chromosome number". In long-styled flowers, usually triploid endosperm is formed but "a certain amount of parthenogenetic development" occurs in some varieties.

In *F. religiosa* we have noticed germinating pollen grains on the stigmas of the gall as well as the long-styled flowers as was also observed by Condit¹ in *F. carica*. We were unable to follow the pollen tube inside the embryo sac and whether fertilization occurs in the long-styled flowers only or in both types, is under investigation.

We are indebted to Professor P. Maheshwari for advice and comments. Thanks are also due to Dr. J. F. Perkins, Department of Entomology, British Museum (Natural History), London, through whose courtesy identification of the pollinating agent in *F. religiosa* was obtained from Professor G. Grandi, Institute of Entomology, The University, Bologna (Italy).

Dept. of Botany,
University of Delhi,
July 26, 1955.

B. M. JOHRI.
R. N. KONAR.

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INFLUENCE OF THE AMPLITUDE OF SUPERIMPOSED AC VOLTAGE ON ALTERNATING CURRENT POLAROGRAPHY

THE conventional polarograms obtained with dc potentials applied to the dropping mercury electrode (d.m.e.) in a solution containing electro-active substance(s) are smooth S-shaped curves representing the variation of the current i passing through the cell with the applied potential E^1 . They follow a simple relationship,¹

$$E = E_{1/2} + k \ln (i_0 - i)/i \quad (1)$$

where i_0 is the limiting or diffusion current; $E_{1/2}$ the characteristic half-wave potential of the electro-reducible or oxidisable ion; and k , a constant. It follows from (1) that di/dE is maximum at $E_{1/2}$ where $i = i_0/2$; and that the maximum value of the derivative di/dE is a measure of i_0 which, according to Ilkovic equation² or its modified forms,^{3,4} is proportional to the concentration of the ion undergoing discharge. These features are clearly brought out in the studies of alternating current polarography developed recently by Brayer, Gutman and Hacobian⁵; in this a small ac voltage is super-

imposed on the dc potential applied to the d.m.e. The present communication reports for the first time a few detailed investigations on the influence of the magnitude of the superimposed ac voltage on the derivative polarograms (dI/dE vs. E curves); these results appeared to be of marked practical utility in alternating current polarography (*vide infra*).

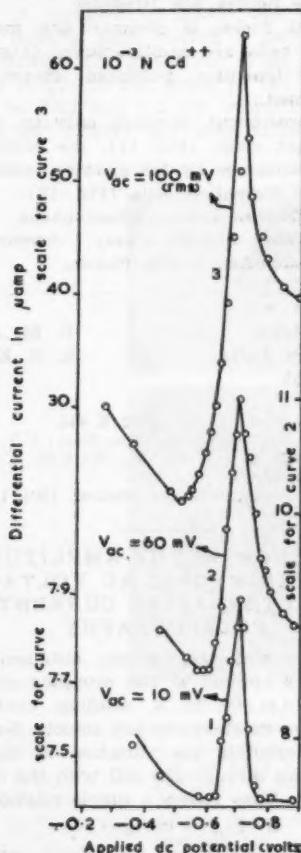


FIG. 1. Derivative polarograms of 0.001 M Cd^{++} in 0.1 N KCl solution at different superimposed ac voltages.

A capillary of the following characteristics was employed: drop time, $t = 4.815$ sec., and mass of the drop, $m = 8.05$ mg. The dc potentials in the range 0 to 2 volts were obtained by suitable potentiometric arrangement. A Leeds and Northrup audio frequency oscillator gave alternating potentials of the required frequency; in the present studies, ac voltages of 500 cycles/sec. were employed. A known ac voltage in the range 10-100 millivolts was superimposed over the dc potential applied to

the d.m.e. which was made negative with respect to the dc potential. The details of the electric circuit employed by the present authors will be given elsewhere; it would suffice here to mention that the alternating current flowing through the system was isolated, amplified and measured by a sensitive current measuring device.

Fig. 1 gives a typical series of results representing the derivative polarograms due to the reversible reduction of Cd^{++} ions in 0.1 N KCl used as supporting electrolyte; these polarograms refer to the electrode process in presence of air. The potential (E_s) corresponding to the peak or summit of the ac polarograms corresponded to -0.62 volt *vs.* S.C.E. for Cd^{++} in accord with the value reported earlier.⁶ Further E_s , characteristic of Cd^{++} was unaffected by a change in the magnitude of the superimposed ac voltage, V_{ac} (cf. curves 1, 2 and 3, Fig. 1). The alternating current corresponding to E_s increased progressively with V_{ac} , which is to be expected from a general theoretical consideration of alternating current polarography.⁵ A very significant feature of the polarograms (Fig. 1) obtained with different values of V_{ac} is that at low values

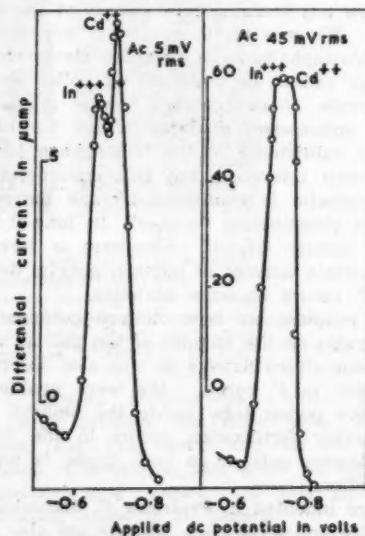


FIG. 2. Separation of derivative polarographic peaks of Cd^{++} and In^{+++} at low superimposed ac voltage (ref. 6).

of V_{ac} the polarograms spread over an appreciably small range of applied dc potentials; thus at $V_{ac} = 10$ millivolts (rms), the wave

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spread (at its bottom) over 0.13 volt (curve 1), while at $V_{ac} = 100$ millivolts (rms) it occurred over 0.37 volt (curve 3, Fig. 1). With low values of superimposed ac voltages, the derivative polarograms are sharp. This feature is of marked importance and elucidates an earlier observation due to Brayer, Gutman and Hacobian⁶ regarding the separation of Cd^{++} and In^{+++} in alternating current polarography. In 0.1 N KCl solution, Cd^{+} and In^{++} have $E_1 = -0.61$ and -0.51 volt vs. S.C.E. respectively; analysis of a mixture of these two components with dc polarography is not possible. Brayer, Gutman and Hacobian⁶ observed two well-defined and separate peaks for Cd^{++} and In^{+++} in ac polarography with low superimposed ac voltages, e.g., 5-10 millivolts; however, at large V_{ac} (e.g., 45 millivolts) Cd^{++} and In^{+++} could not be separated (cf. Fig. 2). No mechanism for this observation was, however, put forward. The present authors' finding (Fig. 1) clearly points out that the possible analysis of Cd^{++} and In^{+++} with low ac voltages is due to inappreciable spread of the waves.

Chemistry Dept., B. D. KHOSLA.
University of Delhi, H. C. GAUR.
Delhi, July 14, 1955. N. A. RAMAIAH.

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ELECTROMETRIC MEASUREMENT OF THE RATE OF OXIDATION OF FERROUS TANNATE BY AERATION IN PRESENCE OF VARIOUS STRONG ACIDS

KAROLY IPOLYI¹ determined the acidity of the tannin inks by measuring its electric resistance by means of the Wheatson's bridge, but in the present work the influence of concentration (< 0.01 N) of various strong acids on the rate of oxidation of aqueous ferrous tannate solution by bubbling air was determined electrometrically.

20 ml. of the solution containing 1.82 g. of pure tannic acid (Merck) in 50 ml. of distilled water were introduced in the conductivity vessel, containing a known weight of ferrous sulphate (0.279 g.) and stirred. The air from the aspirators got by displacement method after de-

hydrating through fused calcium chloride was bubbled through the solution at the rate of 108 bubbles per minute, i.e., 1.0625 litre per hour.

Air supply was disconnected and the oxidation-reduction electrode and the agar-potassium chloride bridge were lowered into the solution at the time of taking reading, after every 10 minutes. After oxidation by air for 2 hours, 5 ml. of 4 N hydrochloric acid were added in order to keep the concentration 5 N and the extent of oxidation was determined by titrating potentiometrically the air-oxidised solution, against standard $KClO_3$ as suggested by Balwant Singh.²

The colloidal particles of ferric tannate in suspension obtained by oxidation in acidic solution were found to possess positive charge in the absence, as well as, in the presence of acids, proving that the increase in the time of sedimentation of ferric tannate particles with increase in concentration of acid is due to peptisation and increase in acid concentration. The oxidation in the case of hydrochloric and sulphuric acids is quicker in the beginning and slows down after 45 and 50 minutes respectively. In the case of 0.2 N HCl the oxidation is very slow from beginning to end and for 0.1 N HCl it slows down after 70 minutes. It was found that oxidation goes on decreasing with increase in concentration, but after a certain time, the rate goes on decreasing for all concentrations.

Ferrous-tannate solution in the presence of low concentrations of hydrochloric and sulphuric acids, after oxidation for 2 hours, on titration with 0.1 N potassium chlorate showed conversion to ferric tannate corresponding to the first break at 5-6 ml. of potassium chlorate. Tannic acid, the second oxidation product, corresponds to the second break at 9-10 ml.

It is observed in all cases from oxidation potential graphs that its value increases with concentration of the acid, while R. S. Carter and F. H. Clews³ observed that oxidation potential of mixtures of ferrous chloride and ferric chloride in concentrated solutions of acid, decreases with the increase in concentration. This was attributed to the removal of ferric ions for formation of complex salts between ferric chloride and hydrochloric acid, but in this case no such complex salt formation with acid at lower concentrations took place.

Forest Res. Inst., C. P. DHAMANEY.
Dehra Dun, April 20, 1955.

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REVIEWS

Polarographic Techniques. By Louis Meites. (Interscience Publishers, Inc.), 1955. Pp. xiii + 317. Price \$ 6.00.

Polarography, though barely three decades old, has established itself as a standard method of instrumental analysis in industrial chemical, biochemical and clinical laboratories. Its increasing popularity is not a little due to the rapidity of the estimations combined with the accuracy, which, in most cases, equals and sometimes surpasses that of classical methods. To workers in this field the most authoritative and comprehensive treatise available is the well-known monograph of Kolthoff and Lingane. The volume under review has been planned only as a concise introduction to the theory and practice of polarography and will therefore serve the needs of beginners as a first book on the subject. Its aim is only to supplement and not to supplant Kolthoff's monograph.

The first two chapters which define the scope of polarography and describe the instrumentation provide an easy introduction to the subject. As a knowledge of the theoretical background of polarographic methods is considered essential for a proper mastery of the technique, a lucid exposition of the theoretical aspects is given in two chapters. The chapter on quantitative polarographic analysis, read along with the previous two chapters on half-wave potential data and maxima and their suppression, supply all the necessary information for carrying out polarographic determinations and interpretation of polarograms. Amperometric methods of titration and special techniques like coulometry, millicoulometry and derivative polarography, are dealt with in the last two chapters. A special feature of the book is the number of experiments described with detailed directions at the end of most of the chapters. Appendix A with the title, "Trouble Shooting in Polarographic Circuits", illustrated with numerous defective polarograms and explaining the cause of their defects, will be of special value to beginners for correcting the abnormalities of their curves. Appendix B gives a comprehensive list of data on half-wave potentials and diffusion current constants of inorganic substances, published up to the end of 1954.

One feels that the appearance of a book of this type is a timely reminder of the desirability

of including polarographic analysis in the curriculum in practical chemistry at the level of the Master's Degree course.

A. P. MADHAVAN NAIR.

- (A) **A Manual of Paper Chromatography and Paper Electrophoresis.** By R. J. Block, E. L. Durrum and G. Zweig. (Academic Press), 1955. Pp. v + 484. Price \$ 8.00.
 (B) **Introduction to Paper Electrophoresis, and Related Methods.** By M. Lederer. (Elsevier Publishing Co., New York), 1955. Pp. xii + 206. Price 37 sh. 6 d.

Paper chromatography and paper electrophoresis are two analytical tools in the armoury of research chemists and biologists which have been used extensively in recent years for both qualitative and quantitative analyses. A laboratory manual on paper chromatography alone was published by Block and his colleagues in 1952, but recent advances in electrophoretic technique as also the innumerable application of paper chromatography reported in recent literature have induced Block, Durrum and Zweig to come out with a new manual dealing with both paper chromatography and paper electrophoresis.

For a general and introductory treatment of the subject of paper electrophoresis and related methods, Lederer's book can be considered very satisfactory. This book has been written with a view to assist generally the investigators in the fields of analytical, organic, inorganic, radiochemistry and biochemistry. Thus, details have been given in this book under different chapters for the effective separation by the technique of paper electrophoresis, of organic acids, carbohydrates, alkaloids, proteins, nucleic acids, antibiotics, dyes and inorganic compounds. However, the extensive work carried on serum proteins and other clinical applications are only referred to and not discussed in very much detail in this volume. On the other hand, Dr. Durrum has, in his treatment of the subject in Block's manual, laid special emphasis on the separation of protein mixtures, particularly of blood serum. Further, the method of continuous electrophoresis developed chiefly by him has been well described with appropriate illustrations and photographs of actual equipment employed. In the reviewer's opinion, therefore, Dr. Durrum's section on electrophoresis serves

as an extremely useful supplement to Lederer's book on paper electrophoresis.

In the section on paper chromatography, Block and Zweig have succeeded in giving a comprehensive account of the theoretical and practical aspects of the technique. Quantitative methods of estimation of spots in paper chromatograms are also described, particularly with the use of photoelectric densitometers. The individual chapters dealing with paper chromatographic separation of amino acids, sugars, purines, porphyrins and a host of miscellaneous organic compounds, have been exceedingly well written and contain exhaustive references to the literature published during the last few years. It is pleasing to note that the authors have referred to the work carried out on various types of paper chromatography in different institutions in India and published in *Current Science* and other scientific journals in this country, and have even reproduced some tabulated data from recently published literature (p. 300). Further, details of solvent systems, general methods of effective separation of mixtures of biological materials and organic compounds and the R_f values of hundreds of compounds obtained under different experimental conditions have all been incorporated in this manual. Separation of inorganic compounds by means of paper chromatography has also been dealt with in a separate chapter.

In conclusion, it may be said that both these books will undoubtedly prove to be extremely useful to those who wish to know the basic principles and methodology of the twin techniques of paper chromatography and paper electrophoresis, and also to those who wish to have them as ready sources of reference for detailed procedures, and for data required in connection with the effective separation of organic, inorganic and biological materials.

P. S. SARMA.

New Methods in Analytical Chemistry. By Ronald Belcher and Cecil L. Wilson. (Chapman & Hall), 1955. Pp. xii + 287. Price 30 sh.

Progress in analytical chemistry has been phenomenal during recent years. Although some good books dealing with instrumental methods such as spectrophotometry, spectrography, and polarography have appeared in the last few years, a text-book dealing with the newer developments of classical analytical methods has been a long-felt need. This book therefore is a valuable supplement to standard text-books as well as to specialised books dealing with instrumental methods. The authors

have justifiably claimed to have incorporated considerable non-text-book matter.

The book is divided into seven chapters entitled respectively: Separation by Precipitation; Separation by Extraction; Inorganic Precipitants; Organic Reagents; Indicators; Titrants and Miscellaneous Methods—the titles given being very suggestive. The general principles and the analytical techniques are critically examined at the beginning of each chapter, and these are followed by detailed descriptions of the individual methods. Due stress is laid on the novel technique of precipitation in a homogeneous medium. The details given for the synthesis of the less common reagents are particularly helpful. The authors have themselves tested a large number of the methods described, while the rest of the methods suggested are those recommended by workers of repute.

The authors have accomplished the great task of selection and critical examination of the enormous amount of work done during recent years. The reviewer has no hesitation in recommending this book for study by every one interested in analytical chemistry. The get-up is very good.

K. R. K.

Antibiotics Annual. Edited by Henry Welch and Felix Marti-Ibanex. (Medical Encyclopædia, Inc.; Distributors outside U.S.A.: Interscience Publishers), 1955. Pp. ix + 1154. Price \$10.00.

This volume documents the proceedings of the Second Annual Symposium on Antibiotics sponsored by the U.S. Department of Health, Education and Welfare, Food and Drug Administration (Division of Antibiotics) and held on October 25-29, 1954, in Washington DC. Those who have gone through the last *Annual* were eagerly waiting for the present volume, but the reviewer at least was not prepared, in spite of his most optimistic estimate, to receive a bulky volume of 1160 pages containing 172 contributions. It looks as if "all antibiotic investigators refuse to rest on their laurels; they are pressing forward in their relentless searches..." The output of scientific work on the antibiotics seem to run parallel to the output of penicillin in U.S.A. which was 29 lb. in the first year of manufacture and 372 tons in 1953. Up till 1946 fairly easily, and up till 1948 with some strain, the reviewer could read all the papers on the antibiotics in the easily accessible journals but today even keeping one's hand on the pulse of this all-pervasive field, even though the medium of the abstracts and reviews, is becoming a very

taxing and heart-rending job. It is in this context that the great value of this *Annual* becomes evident. As pointed out by the editors, "The importance of the contributions made by this meeting to medical science and clinical thinking is reflected by the fact that leading representatives from 36 countries' journeyed here to gain the most contemporary findings and opinions as related to antibiotics". The contributions have a bias towards the clinical side and in this volume there is wholesome food for even the most voracious hunter for new ideas and information. The reviewer who has gone through the volume with great eagerness can do nothing more but to underscore the statement of the editors: "No brief summing up can give an adequate idea of the scientific importance of the contributions made in this symposium." The sponsors of the symposium deserve the warmest praise and gratitude from the workers in the field of antibiotics, and we hope that this symposium will be a regular annual or biannual feature—only the venue could be in different countries, East and West. Why not an International Geneva Conference in Antibiotics as a sequel to the recent one in Atomics? As has been very aptly pointed out by President Eisenhower in his message, "Such international co-operation in years ahead may bring ever closer a world of peace and happiness for all mankind".

The present volume is probably a "Best-buy" for \$ 10 in U.S.A. but very few in other countries can afford to buy it. The serious question arises: "What then is the function of such a volume?", unless it is retorted that it is far cheaper than making a journey to Washington to know what all happened there.

K. GANAPATHI.

Centrifugal and Rotodynamic Pumps. By H. Addison. (Chapman & Hall), 1955. Pp. x + 530. Price 50 sh.

Professor Addison has included in his treatment a wide range of pumps, including not only centrifugal pumps, but all types of impeller pumps where the impeller imparts a tangential acceleration to the liquid and builds up a head. So the treatment covers centrifugal pumps, propeller pumps, fans and blowers, thus including in one group the entire range of the pumping plant which works on the rotodynamic principle.

Chapters are devoted to the design of the impellers, bearings, sealing rings, stuffing boxes and the volute casing. Multi-stage pumps are discussed as well as some special pumps. A

chapter is devoted to the testing of pumps, while separate chapters deal with the performance and installation of pumps. The book will therefore be of great help not only to students and technologists, but also to manufacturers interested in the design of pumps, and to others interested in the proper choice, installation and use of pumps.

There is a chapter on allied machinery dealing with electric motors, turbines and engines suitable for driving pumps, with a brief discussion on some types of valves and fittings used in pumping installations. This is naturally very brief and limited, as the purpose of the book is more to discuss the pumping machinery. Some additional information however on piping systems, pipe fittings and frictional drops in pipes and fittings, would have added to the usefulness of the book as a reference book on pumps and pumping systems as a whole.

There is a collection of worked examples at the end of the book which deals with several practical aspects of pumping installations. This is found to be of great interest to the student of hydraulics, as well as to the engineer in the installation and proper use of pumps.

The book, as a whole, will be a welcome addition to a technical library especially in view of the widening field of industrial pumps and pumping installations.

V. S. J.

Further Studies on Cereal Rusts in India, Part II. By K. C. Mehta. (Scientific Monograph No. 18, The Indian Council of Agricultural Research: The Manager of Publications, Delhi), 1952. Pp. vi + 368. Price Rs. 10-2-0 or 16 sh.

This monograph is a posthumous publication and summarises the second phase of the Cereal Rust investigations (1930-38) by the late Professor K. C. Mehta. The first monograph (No. 14) dealt with the immense world problem of physiologic races in the cereal rust and the dual problem of alternate hosts and over-summering of rust spores. The monograph under review is the outcome of many years of patient work and includes many maps indicating wind-trajectories and the author has certainly presented masses of data over many parts of undivided India in an attempt to explain the progress of the disease.

Prof. Mehta's conclusions as a result of all his studies are well known and had he been spared to us for some more years he may have canalised all his thoughts and made further

contributions in this growing field of research. However, that was not to be. Nevertheless, the reviewer feels it necessary to recapitulate the major conclusions of Prof. Mehta based on statistical interpretations of his impressive figures covering many tables correlating his spore trap analyses with prevailing meteorological observations. What appears as Dr. Mehta's weightiest argument is that the inoculum is re-introduced on the plains by katabatic winds that bring down the rust inoculum from all hills of about 6,000' altitude and act as foci of infection for each of the three rusts. Statistically, the case of 'relevant winds' in relation to spore showers for black and brown rusts was fairly high and rather low for yellow rust. The most important foci for dissemination of rust inoculum, according to the author, lay in Central Nepal, the Nilgiris and Palni Hills owing to early crops being grown there and from these areas there was an early dissemination to the Indo-Gangetic Plain and Peninsular India.

Prof. Mehta has not only lived up to the exacting demands of such a difficult and complicated long range scientific enquiry but has been a pioneer in India's early scientific achievements. With the great strides being made in the study of aerobiology and evaluation of data on air spora in post-war years, much of the aerobiological data collected by somewhat rudimentary equipment then available to science have to be reviewed by contemporary scientific workers in the field. One of Prof. Mehta's major conclusions, viz., that there is little likelihood of the dissemination of rusts to India from across the seas nor is there any evidence of the inoculum coming from adjacent countries except Nepal, needs careful and urgent scrutiny from the breeder's point of view. With our frontiers shortened and with the important geographical position we occupy in Asia it should be possible to use our scheduled flights and our network of air system, both internal and trans-continental, by devising compact spore trap units (by studying aerodynamic principles) in a bid to compile more data on this important and fascinating subject of air spora.

I commend this monograph for careful study by mycologists. Today it probably represents nothing more than a working hypothesis and is an introduction, as it were, to this science of air-borne rust dissemination. I only wish that the proof-reading and general get-up of this publication were better than what it is but considering that the data is a scientific diary of

a long-range investigation on the subject, chronologically arranged, it will be received well for its usefulness by future aerobiologists in this country and abroad.

T. S. SADASIVAN.

Books Received

New Age Determinations by the Lead Method, Vol. 60, Art. 3. By J. Laurence Kulp, George L. Bate and Bruno J. Geletti. (Annals of the New York Academy of Sciences.) Pp. 509-20. Price \$ 0.50.

Hydrocortisone, Its Newer Analogs and Aldosterone as Therapeutic Agents, Vol. 61, Art. 2. (Annals of the New York Academy of Sciences,) Pp. 281-636. Price \$ 4.50.

Qualitative Organic Analysis and Scientific Method. By A. McGookin. (Chapman & Hall), 1955. Pp. vii + 155. Price 15 sh.

The Quantitative Analysis of Drugs. Second Edition. By D. C. Garratt. (Chapman & Hall), 1955. Pp. xv + 670. Price 70 sh.

Symposia of the Society for Experimental Biology, No. 9, Fibrous Proteins and Their Biological Significance. (Cambridge University Press), 1955. Pp. vi + 370. Price 50 sh.

Genetics and Cytogenetics in Drosophila funbris. By Ann-Margret Perje. (Stockholm, ALB, Bonniers, Boktryckeri), 1955. Pp. 12.

A Nucleo-Cytoplasmic Anomaly in Drosophila melanogaster Causing Increased Sensitivity to Anaesthetics. By Bertil Rasmuson. (Berlingska, Boktryckeriet), 1955. Pp. 148-208.

X-Ray Studies on Antimony (III) Oxide Halogenides and Some Related Compounds. By Maja Edstrand. (Stockholm, Esselte AB), 1955. Pp. 230-45.

Traffic Forecast and Calculation of Receipts for Motor Road Connecting Sweden and Denmark, No. 92. By Torsten R. Astrom. (Transactions of the Royal Institute of Technology, Stockholm, Sweden), 1955. Pp. 87.

Reflection of Electromagnetic Waves from Thin Metal Strips, No. 91. By Kristen Lindroth. (Transactions of the Royal Institute of Technology, Stockholm, Sweden), 1955. Pp. 62.

Discovery Reports—Euphausiacea of the Benguela Current, Vol. XXVII. By Brian P. Boden. (Cambridge University Press), 1955. Pp. 337-76. Price 12 sh. 6 d.; *Alepisavroid Fishes*. By N. B. Marshall. Pp. 303-36. Price 12 sh. 6 d.

Surgery of the Heart and Thoracic Blood Vessels. (The Medical Dept., The British Council, 65, Davis Street, London W. 1), British Medical Bulletin, Vol. 11, No. 3 (1955). Pp. 171-242. Price 15 sh.

RECENT TRENDS IN APPLIED MATHEMATICS*

THIS volume contains the manuscripts resulting from the invited addresses delivered at the symposium on Applied Mathematics held at the University of Chicago on 29 and 30 April 1954. The value of the papers in the collection has been enhanced by the fact that the manuscripts were drafted after the conference, and consequently included material which was brought out during the interesting discussions. The symposium was sponsored jointly by the American Mathematical Society and the Office of Ordnance Research, U.S. Army, and looking at the names of the participants in the symposium, it is evident that the conference must have stimulated contacts between scientists in the Universities and those in Government Institutions.

There is an amazing variety in the topics dealt with in the book, and this variety comes as an eye-opener to those nurtured in the old classical school of applied mathematics. The first article on Operations Research by P. M. Morse serves to emphasise correctly the nature, the importance, and the techniques of this new field of activity. He has considered three typical problems, viz., the waiting line or queueing theory and the associated Monte Carlo procedure, the linear programming problems, and problems amenable to Neumann's game theory. Finally a new type of problem called the theory of the optimum distribution of effort has been set up, and its intimate connection with applications to military operations, and industry or business activities has been fully explained.

The next two articles by Neyman and Hartley respectively are statistical in character. Neyman has satisfactorily settled a fundamental question relating to modern mathematical statistics by showing that it can be based on the theory of inductive inference which should be considered to belong to the conceptual and not phenomenal, sphere of thought, and that it can be applied in all cases where a stochastic model has been adopted to represent a given class of phenomena. This has been illustrated in an illuminating way by considering the phenomenon of neutral V-particles in nuclear physics, and their decay. The other article by Hartley on recent developments in analysis of variance gives a comprehensive survey of the subject, and presents the most recent developments relating to this valuable statistical technique.

Papers 4-6 relate to computational methods, and numerical analysis. In a brilliant paper on the motivation for working in numerical analysis, John Todd has discussed most of the important and attractive topics that can be handled by this method. Problems in game theory and Monte Carlo processes are shown to be amenable to computational procedures. Recent activity in numerical analysis is illustrated by pointing out biological applications, and applications to combinational analysis, number theory, algebra and topology. Iterative computational methods have been explained by M. R. Hestenes, and shown to be an improvement on the usual methods. The advent of high speed automatic digital computers enables the employment of such methods, and Hestenes has indicated applications to matrix inversion, and matrix eigen-values. Perhaps the finest indication of what has been achieved by numerical computation is given in the article by A. A. Bennet by considering Ordnance problems. He has listed some forty of the most important computing projects undertaken in the Ballistic Research Laboratories of the U.S. Army Ordnance Corps at Aberdeen Proving Ground which operate the best equipped modern high-level computing facilities in the world.

What is more interesting than the wonderful variety of these topics is the awakening of interest, resulting from computational techniques, in many long-neglected fields of pure mathematics. The prophecy of Hermann Weyl that the methods of mathematics considered as formal logic have reached saturation limits, and that new advances can be expected with the help of devilishly fast computing machines, appears to be coming true. Bennet has also indicated very correctly that the problems of a computing laboratory are problems of personnel, not of clerks who can come running at the call of a push-button, but of scientists who can devise the right push-button for slave machines. That these are, after all, slaves is well brought out by the fact that while the fastest modern computing machine would require something over 108 years of continuous errorless operation to invert an ordinary matrix of order 20 by the traditional method of determinants and co-factors, a better suited method can be devised to accomplish this inversion in a few hours.

Papers 4, 8 and 9 relate to what might be called classical applied mathematics. J. E. Mayer has listed two unsolved problems of statistical mechanics, one in which the mathematical equation can be correctly formulated but cannot be solved in a general way although

* *Transactions of Symposia in Applied Mathematics*, Vol. II. Sponsored by The American Mathematical Society and Office of Ordnance Research, U.S. Army, No. 2. (Interscience Pub.), 1955, Pp. 216, Price \$5·00.

approximate methods can be used, and another which cannot be set up mathematically because of logical difficulties, although particular cases can be specifically solved. It is shown that the latter case is due to the fact that a simple and useful definition of entropy which can at least lend itself to computational procedures is lacking, and that a fundamental mathematical clarification is therefore needed. In a paper on the simplest rate theory of elasticity, Truesdell has set up a new type of what he calls the theory of the isotropic hypo-elastic body of grade zero, a non-linear field theory which is dynamically admissible for strains and rotations of any magnitude. The theory is a natural extension of the classical one, and appears more satisfactory than even the usual finite strain theory. The notion of stability of mechanical systems has been subjected to a thorough analysis in a paper by J. J. Stoker, and a most interesting example, where stability considerations arise, is given of a new type of synchrotron which would increase the energy of the particles used to bombard atoms by a very large factor. The question of stability which, here, is equivalent to the existence of relatively small deviations from a circular orbit, requires an adequate theoretical analysis since an experimental check cannot be carried out, for the individual particles go around the synchrotron hundreds of thousands of times, and even the

most modern high speed digital counters have far too little capacity to carry out numerical computations with accuracy over trajectories which are so long.

The last two papers, are devoted to differential equations and differential operators. In a long paper of over 60 pages, F. J. Bureau discusses comprehensively the abstruse notion, due to Hadamard, of the finite part of a divergent integral, and considers Cauchy's problem for the wave equation, and the Euler-Poisson-Darboux equation. Elegant and general solutions are obtained and numerous applications are indicated. The paper closes with a very valuable and comprehensible bibliography. In the last paper of the series, W. Feller discusses the most general class of operators with certain characteristic properties, and shows that these operators can be viewed in a new light as operating in the Banach space of measures where the notion of self-adjointness becomes irrelevant. It is also shown that the introduction of these generalised parameters achieves a considerable simplification and unification of the theory.

The material covered in this symposium is sure to be of the highest significance to all workers in modern applied mathematics and allied fields.

B. S. MADHAVA RAO.

SCIENCE NOTES AND NEWS

Kalinga Prize Award to Dr. August Pi Suner

Dr. August Pi Suner, Spanish Physiologist and Director of the Institute of Experimental Medicine at the University of Caracas, Venezuela, has been awarded the 1955 Kalinga Prize for his work in popularizing science in Spanish-speaking countries.

Born in Barcelona in 1879, Dr. Pi Suner joined the University of Caracas as a Professor of Physiology following a distinguished career in teaching and in research in Spain. In 1922, he received the Achucarro National Prize in Spain for his research in the physiology of the nervous system and, in 1948, he was awarded the Prix Pourat of the Paris Academy of Sciences for his book, *The Vegetative Nervous System*.

In addition to his scientific works, Dr. Pi Suner is the author of an extensive series of books intended to bring science within the grasp of the layman. Among his works which have been translated into English are *The Bridge*

of Life and Classics of Biology. He has been widely translated into French and above all, he has made an important contribution to the popularization of science in the Spanish-speaking countries.

Synthesis of Benzene by Irradiation of Acetylene

Benzene has been synthesized from acetylene by bombardment with β -rays from tritium at the Laboratories of the General Electric Co., U.S.A. At 26° C., about 72 molecules of acetylene are converted either to benzene or cuprene per 100 e.v. of radiation energy. As the benzene yield is about 5 molecules per 100 e.v., about 21% of the acetylene consumed goes into the formation of benzene. The fraction of acetylene converted to benzene is found to be independent of acetylene pressure and radiation intensity.

Birbal Sahni Institute of Palaeobotany, Lucknow

The Eighth Scientific Meeting of the Palaeobotanical Society will be held at the Institute's premises on 21-22 January 1956. The programme will include lectures, reading of papers and discussions. Palaeobotanists from all over India are expected to participate.

Artificial Aurora Borealis

A group of Italian scientists intends to create within the next 2 or 3 years an artificial aurora borealis that will reproduce in temperate climates the phenomenon as it is observed in the Arctic. The aurora will be created by the radio waves transmitted into the ionosphere. This artificial aurora borealis will be an Italian contribution to the International Geophysical Year.

Bibliography on the Infra-Red and Its Applications

A 374-page bibliography on infra-red radiation and its multitude of applications has been made available to the public by the Office of Technical Services, U.S. Department of Commerce. The bibliography includes all references to published literature on the subject from 1935 to 1951. The classification proceeds from infra-red theory and general infra-red-optical properties through the various elements and components of infra-red equipment, infra-red spectroscopy and photography, to its various applications in science, technology, the arts and industry. *Infra-red: A Library of Congress Bibliography*, (PH 111643) may be ordered from OTS, U.S. Department of Commerce, Washington 25, D.C., price \$ 3.

Soviet Physics—In English Translation

The American Institute of Physics, 57, E.55 St., New York, will shortly commence publication of *Soviet Physics—JETP*, a periodical translation of research reports appearing in the Russian language, *Journal of Experimental and Theoretical Physics*. The National Science Foundation has granted funds to help finance the first year's operations. The Editor will be Robert T. Beyer of the Department of Physics, Brown University, where the editorial office will be located.

Sleep in Ruminants

During digestion experiments with cattle, C. C. Balch (*Nature*, 1955, 175, 940) observed that the animals never appeared to sleep and

always used the same lying position. Throughout the night, periods of lying and resting are interspersed with periods of standing and of rumination. Therefore, if sleep occurs at all in cattle, it must be of the polyphasic type. As a result of his studies, Balch concludes that, under normal conditions of management, healthy adult cattle and sheep, and probably ruminants in general, sleep little, if at all. He suggests that this ruminant peculiarity may be related for upright maintenance of the thorax in proper functioning of the reticulorumen and to the requirement of time and consciousness of rumination.

New Limestone Deposits

A large deposit containing approximately 269 million tons of limestone has been discovered by the Geological Survey of India in the Nandigama Taluk of Krishna District in the Andhra State.

A good deposit of marine limestone of recent age has also been found to occur over an area of about $1\frac{1}{2}$ square miles near Rameshwaram in Ramanathapuram District in the Madras State. The limestone, which is in the nature of an unraised coral reef, ranges in thickness from 3 to 10'. The analyses show that the limestone is of good quality. The deposit is likely to yield more than 5 million tons of limestone suitable for cement manufacture.

Hyla Process of Water Purification

Although the process of treating water with silver salts was originally developed in Switzerland, the principle has been improved by Salem Brosius, Inc., Pittsburgh, Pennsylvania, with successful control of the amount of complex silver salts used with safety. The improved process, known as 'Hyla Process' of water purification consists of silver salts deposited on a carrier, such as activated carbon. The water is treated by a short retention of the salts in the system. Experiments at John Hopkins University, Baltimore, Maryland, show that silver salts are effective against bacteria, control slime, and impart residual bactericidal properties to the water. Water so treated has been found to be safe for many applications in the food industry to preserve fruit, vegetables and fish; in dairies, canneries, and beverage plants where equipment must be maintained according to high sanitary requirements; and in the manufacture of ice used to preserve products during transit. The treated water is tasteless, odorless and non-corrosive. —(U.S. Technical Digest, D. 4448/2.)

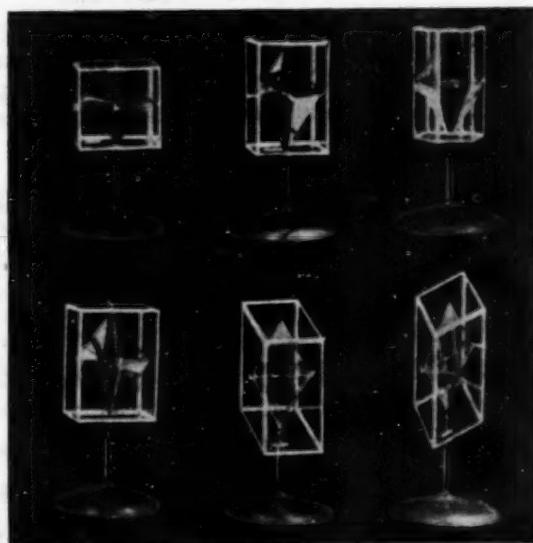
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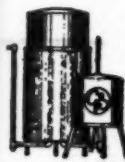
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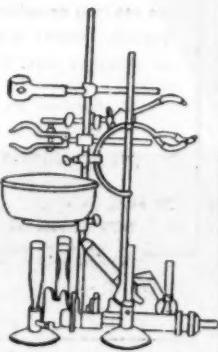


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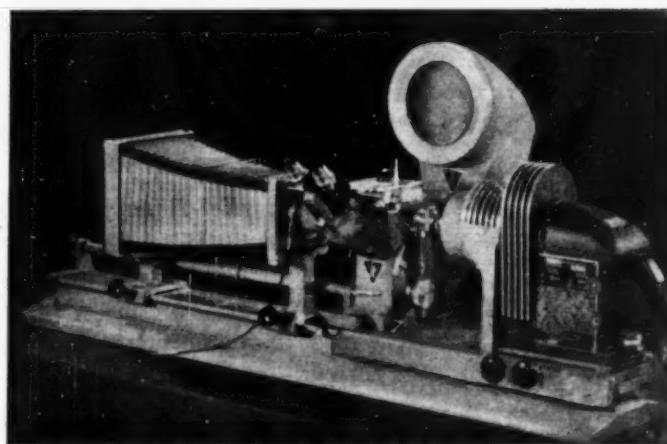
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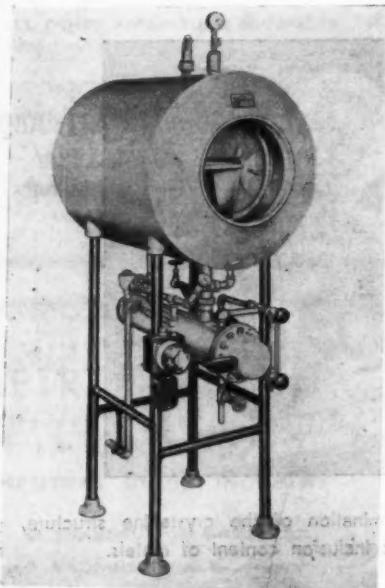
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